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PREVIEWS

Next ElectronicsWeek

Surface mounting gains adherents in components industry

The surface-mounting technique for attaching components to printed-circuit boards is beginning to have an impact on the entire components industry. Though manufacturers of discrete semiconductors as well as those that make passive chips have been supplying surface-mountable components for some time, the rest of the industry is only now joining the trend. Today, a slight 5% to 6% of all electronic components used in the U.S. are surface mounted, but the figure should climb to 70% by 1990. For an examination of the means and the motives, see next week's *ElectronicsWeek.*

Mass storage gets a new push

In mass storage, the idea is to increase capacity at a lower cost per megabyte. But often, what can be engineered cannot be manufactured. The practical reality is that only three techniques can increase the capacity of Winchester disk drives. The first is simply to add more disks and heads, which adds cost. The second is to pack more tracks into each inch of disk, which requires too much development effort. The third is to increase the number of bits per inch, which is the preferred method. Now, more efficient encoding schemes are offering increased disk capacity at little or no extra cost. How this is being done is described in the next issue of *ElectronicsWeek.*

Looking ahead in ElectronicsWeek

Flexible modular approach brings down cost of ATE

Automatic test equipment can be devilishly expensive, effectively closing it off to manufacturers who must test small quantities of different subsystems. But a new approach, in which modules are interchangeable, opens the ATE closet for them. Get the details in an upcoming issue of *ElectronicsWeek.*

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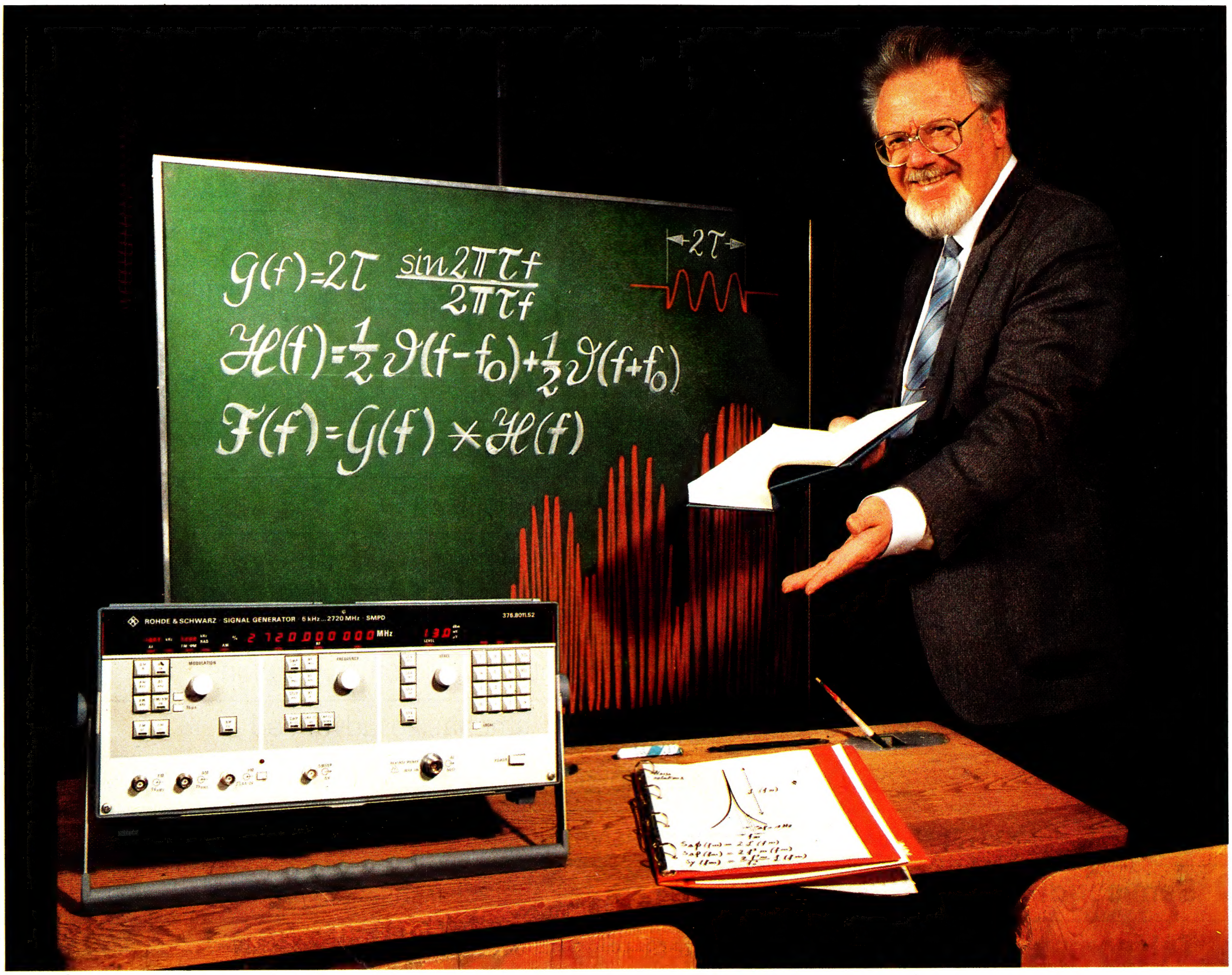

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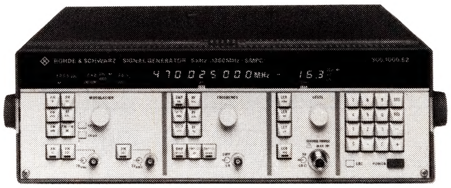
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Market has billion-dollar potential/24

Technology Around the World

Networks ISDN spawns a batch of ICs. Even though standards for the integrated services digital network are still incomplete, semiconductor houses are starting to count their chips **16**

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Military More is less in strategic command, control, and communications. Megabuck upgrades for the country's C^3 system emphasize advanced technology. But they could be insufficient to overcome the problems that have turned the system into an expensive lemon **18**

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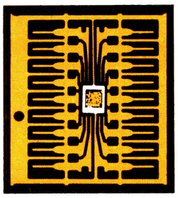

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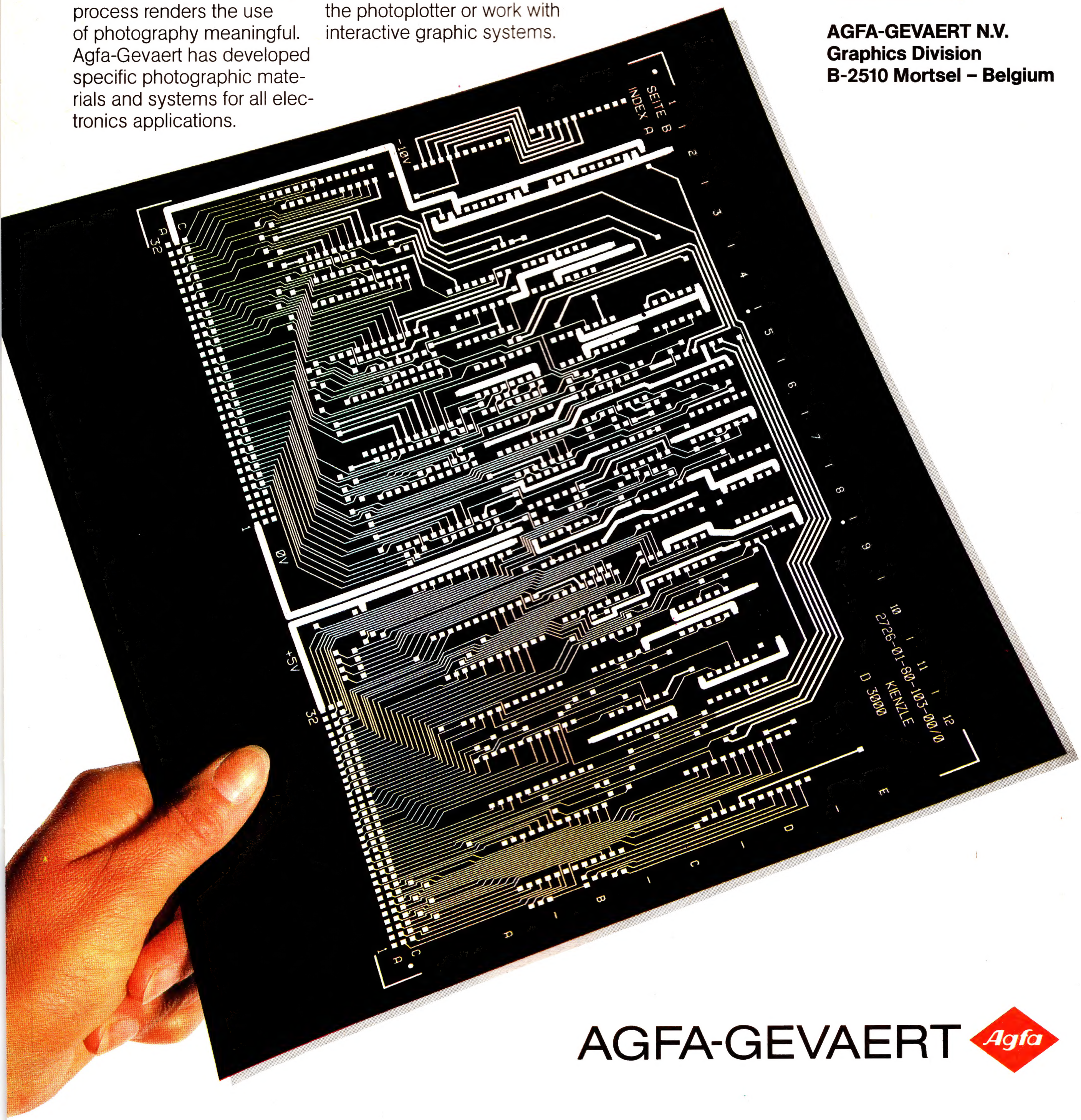

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Meetings

Computer Crime Conference, Data Processing Management Association *et al.* (Data Processing Management Association, Education Foundation, 505 Busse Hwy., Park Ridge, Ill.), Holiday Inn Civic Center, Lubbock, Texas, May 6-7.

Industrial Information Architecture Forum, Gartner Group Inc. (72 Cummings Point Rd., Stamford, Conn.), Loews Anatole, Dallas, May 13-14.

Expert Systems and Their Applications, Agence de l'Informatique (Jean-Claude Rault, Agence de l'Informatique, Tour Fiat—Cédex 16, 92084 Paris-La Défense, France), Palais des Congrès, Avignon, France, May 13-15.

C-85 International Conference in C, Lifeboat Association *et al.* (1651 Third Ave., New York, N.Y. 10128), Ramada Renaissance, San Francisco, May 13-15.

HDTV '85—High Definition Television Colloquium, The Government of Canada (Marg Coll, Conference Coll Inc., 1138 Sherman Dr., Ottawa, Ont., Canada K2C 2M4), Contress Centre, Ottawa, May 13-16.

First International Symposium on Automated IC Manufacturing, Electrochemical Society (Asyst Technologies Inc., 46309 Warm Springs Blvd., Fremont, Calif. 94539), Royal York Hotel, Toronto, Ont., Canada, May 13-17.

California Computer Show, Norm De Nardi Enterprises (289 S. San Antonio Rd., Suite 204, Los Altos, Calif. 94022), Hyatt Hotel, Palo Alto, May 14-15.

Electroworld '85, Electrical Representatives Club of Denver and Instrument Society of America (Minetta A. Miller, Electroworld, 909 17th St., Suite 418, Denver, Colo., 80202), Currigan Exhibition Hall, Denver, May 14-15.

1985 Symposium on VLSI Technology, Japan Society of Applied Physics and IEEE (Yoshio Nishi, Toshiba Corp., 1, Komukai, Toshiba-cho, Saiwaiku, Kawasaki 210, Japan), Kobe Convention Center, Kobe, Japan, May 14-16.

Digitech '85, Instrument Society of America, ISA's District One (P.O. Box 12277, Research Triangle Park, N.C. 27709), Bayside Exposition Center, Boston, May 14-16.

Fourth Test & Measurement World Expo, Test & Measurement World Expo (Meg Bowen, Conference Director, Test & Measurement World Expo, 215 Brighton Ave., Boston, Mass. 02134), San Jose Convention Center, San Jose, Calif., May 14-16.

Fifth International Conference on Ion and Plasma Assisted Techniques, CEP Consultants Ltd. (IPAT '85, CEP Consultants Ltd., 26 Albany St., Edinburgh EH1 3QH, UK), Munich Penta Hotel, Munich, May 14-16.

Electromagnetic Energy Policy Alliance 1985 Meeting, Electromagnetic Energy Policy Alliance (EEPA, 1800 M St. N.W., Washington, D.C. 20036), Hotel Intercontinental, San Diego, May 14-17.

22nd AIM Technical Conference and Exposition, Association for Integrated Manufacturing Technology (Barbara J. Waldorf, AIM Tech, 111 E. Wacker Dr., Suite 600, Chicago, Ill. 60601), Sheraton Hotel, St. Louis, May 14-17.

Seminars

Network Communication Protocols, Center for Advanced Professional Education (1820 E. Garry St., Suite 110, Santa Ana, Calif. 92705), The Sheraton Heights, Hasbrouck Heights, N.J., May 1-3; Detroit-Plymouth Hilton Inn, Plymouth, Mich., May 6-8.

Symposium on Industry-Wide Bar Code Standards, Automatic Identification Manufacturers Inc. (1326 Freeport Rd., Pittsburgh, Pa. 15238), Radisson Mark Plaza Hotel, Alexandria, Va., May 10.

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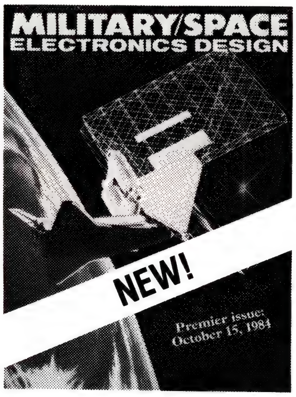

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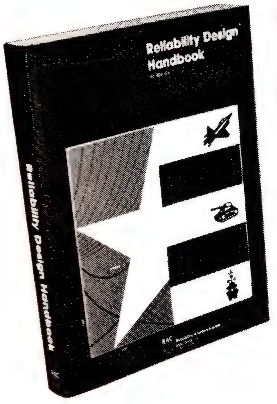

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Editorial

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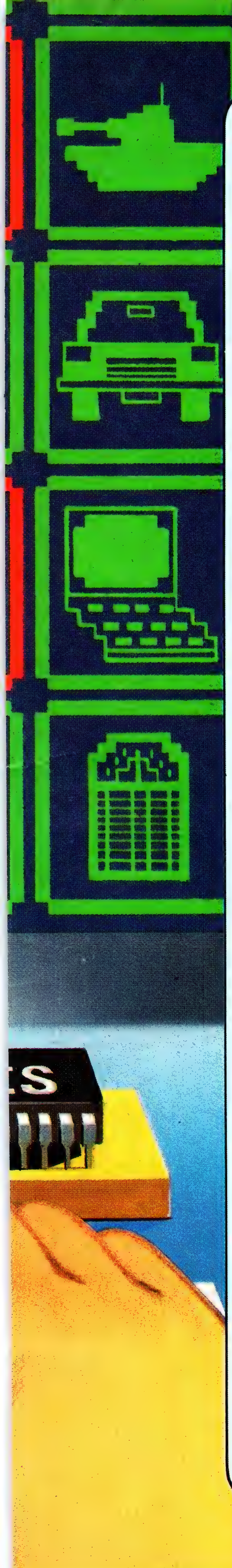

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The ET 9400 family : Common characteristics : 4-bit configuration, 3 stack levels, 8 two-directional I/Os, internal counter with serial I/O, software compatibility, double source availability, NMOS version : 4.5 to 6.3 V, CMOS version : 2.4 to 5.5 V.

Reference	Technology Used	ROM x 8	RAM x 4
ETL 9410/ 11	NMOS	512	32
ETC 9410/ 11	CMOS	512	32
ET 9420/ 21/ 22	NMOS	1024	64
ETL 9420/ 21/ 22	NMOS	1024	64
ETC 9420/ 21/ 22	CMOS	1024	64
ETL 9444/ 45	NMOS	2048	128
ETC 9444/ 45	CMOS	2048	128

The EF 6804 family : Common characteristics : 8-bit serial configuration, memory-mapped I/O, self-testing mode, bit manipulation, 4 stack levels, 8 addressing modes, double source availability for most items. Runs on 2 to 6 V in CMOS version, 5 V in HMOS version.

Reference	Technology Used	ROM x 8	RAM x 8	I/O
EF 6804P2	HMOS	1024	32	20
EF 6804J2	HMOS	1024	32	12
EF 68HC04J3*	HCMOS	2048	124	12
EF 68HC04P3	HCMOS	2048	124	20

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The EF 6805 family : Common characteristics : 8-bit parallel configuration, memory-mapped I/O, self-testing mode, bit manipulation, 15 sub-routine levels, 10 addressing modes, double source available for most items.

Reference	Technology Used	ROM x 8	RAM x 8	I/O	Characteristics
EF 6805P2	HMOS	1100	64	20	
EF 6805P4	HMOS	1100	112	20	RAM stand-by
EF 6805P6	HMOS	1796	64	20	
EF 6805R2	HMOS	2048	64	32	A/ D Converter
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EF 6805U2	HMOS	2048	64	32	
EF 6805U3	HMOS	3776	112	32	
EF 6805CT4	HMOS	4096	240	29	UART RAM stand-by
EF 6805TV	HMOS	6144	96	32	Communication Interface
EF 68HC05E2	HCMOS	0	112	16	Open mode
EF 68HC05CT*	HCMOS	4096	240	32	2 USART

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The EF 6801 family : Common characteristics : 8-bit parallel configuration, enhanced EF 6800 instruction set, 8x8-bit multiplication, serial I/O, 16-bit timer, open or closed mode, double source availability.

Reference	Technology Used	ROM x 8	RAM x 8	I/O	Characteristics
EF 6801	HMOS	2048	128	31	Serial I/ O, timer, stand-by RAM
EF 6801U4	HMOS	4096	192	31	Serial I/ O and timer, stand-by RAM
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EFT MU01	EF 6801 EF 6801/ U4
EFT MU94	ET 94XX and ET 94XXX

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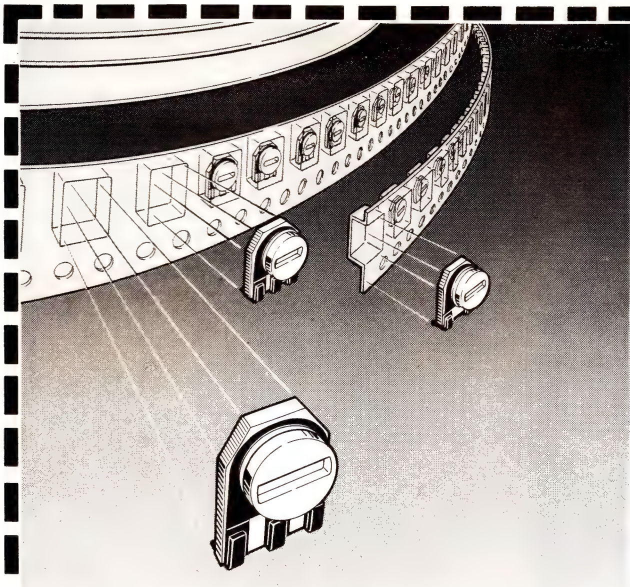

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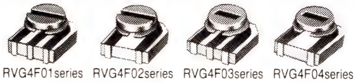

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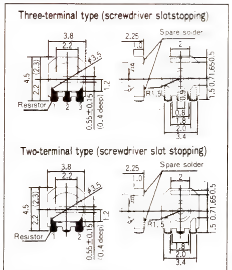

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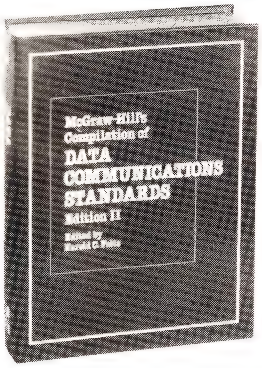
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PC MARKET MAY NOT BE SO BAD

According to a near-industrywide consensus, the personal computer business has hit the skids. Solid backing for this view can be found in news events almost every day: IBM Corp. calling a halt to production of its PCjr; Apple Computer Inc. taking a manufacturing hiatus; red ink streaming from firms large and small that fail to make any headway. But there's a flaw in this bleak perception of the market, points out one expert, whose vantage point at Future Computing Inc. affords a relatively unclouded view. "It's the growth rate that's slowing. The market isn't shrinking, it's growing," says Egil Juliussen, chairman of the Dallas research firm. Contrary to what is virtually taken for granted, "It's better today than it was a year ago." Juliussen delivered his remarks late last month at the Winter Comdex to an audience made up largely of those involved in selling small computers and related equipment—dealers and resale houses that bundle value-added systems for end users. Because they have been badly buffeted by the same tough competition besetting manufacturers, they were skeptical.

Several factors are causing problems in the personal computer business now, according to the way Future Computing sees them. First, much of the slowdown is seasonal, which typically occurs in the wake of a torrid holiday sales pace. Furthermore, the bright prospects of the personal computer business several years ago attracted a plethora of computer retailers. Too many of these proved inexperienced and underfinanced, and their sales and operations soon suffered. Businesses of this type that get in trouble tend to blame their problems on a widespread industry decline rather than on their own shortcomings, so Future Computing's analysis holds. In addition, failing operators get an inordinate share of attention. Adds another Future Computing official, "It's a period of competitive turbulence, but not a shrinking market."

Others support the Juliussen view. Computerland, for example, says it is doing better than at the same time last year, a surprise even to this, the largest computer retail franchiser. Future Computing's analysis is further backed by data collected by Infocorp, another research firm, located in Silicon Valley. It reported that 344,000 personal computers were sold in December, but the total in January dropped to some 167,000 units. By contrast, in March 1984, when Infocorp started gathering data, only 129,000 computers were sold. ☐

Intel sales off sharply from 1984 as industry suffers 'strongest recession'

Reporting that Intel Corp.'s revenue will be "near the break-even point for the current quarter but down dramatically from last year," board chairman Gordon E. Moore explained last week that Intel is suffering now because it "got carried away with the same euphoria that our customers did." With his firm's revenue expected to be down as much as 25% from the $416 million level in the fourth quarter of 1984, Moore says "we're in the strongest recession in this business since 1974." Though he expects Intel to post higher sales in March than in February, he foresees a lot of shaking out in the semiconductor field within the next year, mostly attributable to a "terribly overventured" industry. "There will be mergers, bankruptcies, and layoffs until these excesses are flushed out of the system." ☐

French decision in school project irks other countries

A decision by the French government to favor native vendors in what to date is Europe's largest order for educational computers has touched off a controversy with international implications. Part of a drive aimed at promoting computer literacy, the order will put some 120,000 personal computers worth nearly $200 million in French schools as early as this September. The systems will be supplied by Groupe Bull and Thomson SA; under an alternative proposal, Apple Computer Inc. would have assembled the machines in France. Government sources say both U.S. and British authorities lobbied intensively to be included in the program, which could presage the exclusion of French firms in similar programs in other countries. ☐

Frustrated in past efforts, Trilogy now set to acquire Elxsi

Trilogy Systems Corp.—now a custom-IC house after having been first a supercomputer designer and then a developer of wafer-scale semiconductors—will buy Elxsi, a San Jose, Calif., startup that makes scalar processors. Trilogy was formed three years ago by Gene Amdahl to build a wafer-scale-based competitor to IBM Corp. mainframes. It's been left with plenty of cash but no product after both the computer project and efforts at wafer-scale integration succumbed to technical difficulties. Most recently, Trilogy had planned to buy California Devices Inc., a small CMOS house. But last week, it instead agreed to lay out $46.1 million for Elxsi, which has enjoyed some success with its fast superminicomputer, but which also needs cash after having spent $30 million on the machine's development. One large investor in Trilogy was Digital Equipment Corp., whose VAX machines are a prime target of Elxsi. The deal is expected to take several months to complete. ☐

Compaq brings out communicating computer

Compaq Computer Corp. last week introduced the first product from its Compaq Telecommunications Corp. subsidiary: a personal computer with built-in communications and personal-productivity applications. The 8086-based Telecompaq is a smaller-footprint version of the Compaq DeskPro. However, the machine can communicate over telephone lines, local-area networks, and private branch exchanges while performing personal-productivity functions such as managing calendars, telephone directories, and electronic mail. At the push of a button, the unit goes into a personal computer mode compatible with MS-DOS and IBM Corp. Personal Computer software. The distributor's price ranges from $4,200 to $6,400. ☐

Ericsson unit to expand Sweden's output of CMOS chips

In a bid to end its dependence on foreign-made semiconductors, Sweden has joined with private industry to finance development and production of high-speed CMOS circuits. The Swedish government and AB Rifa, the components unit of L.M. Ericsson AB, have each chipped in 80 million kronor (about $8.5 million) to expand Rifa's capacity to about 20,000 circuits per week by July 1988. The CMOS circuits will meet specifications calling for a 1-ns gate delay—three times faster than the fastest Swedish-made circuits today. Under the agreement, Rifa will make some of its products available at competitive prices to other Swedish firms. Rifa says that it has not selected which foreign cooperation or licenses it will use in building up its capacity. ☐

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ISDN SPAWNS A BATCH OF ICs

Though standards for the integrated services digital network are incomplete, semiconductor houses are counting their chips

☐ *By J. Robert Lineback*

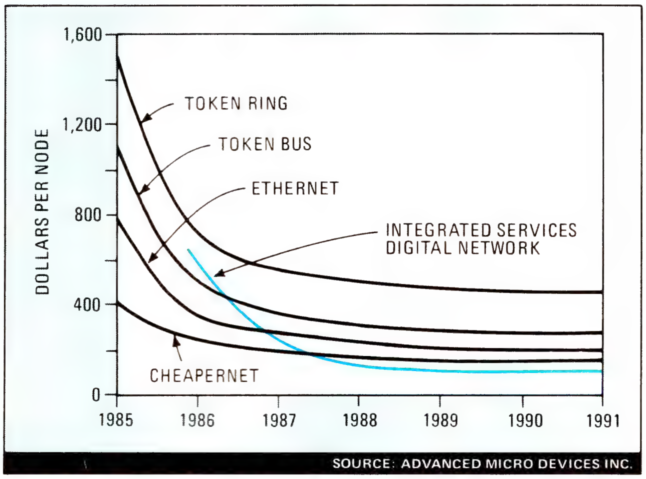
Dallas

Right down the line, telecommunications-chip makers are in rare accord over the benefits that are likely to result from an emerging but still evolving telephony standard known as the integrated services digital network. ISDN's nonproprietary nature not only promises greater interconnectivity of equipment for users, but it is also likely to turn conventional telephone lines into pathways for huge sales of computers and digital-voice systems.

Exactly how and when ISDN will rule voice/data integration is still a tough one to call for most telecom-circuit houses. The full set of specifications for ISDN—though close to completion—has yet to be put into final form by the International Telegraph and Telephone Consultative Committee, known as the CCITT. Many companies are waiting for final specifications and a user demand to surface before committing themselves to ISDN introductions.

It is a proverbial double-bind situation, note telecom-chip marketing officials. ISDN integrated circuits are deemed essential for widespread use of the international protocol. But volume potentials are first needed to send interface circuits down the cost-cutting learning curves.

Hoping to shortcut the predicament are several vocal ISDN advocates, among them AMD, Intel, and Mitel. Last month, Advanced Micro Devices Inc. hosted its maiden ISDN Design Forum in Dallas with the intent to "help push the snowball forward," says Ronald R. Ruebusch, group product marketing manager of AMD's Information Products Division, in Austin, Texas. More than 180 participants attended the forum, which AMD plans to repeat in Europe and Japan this year.



SOURCE: ADVANCED MICRO DEVICES INC.

Down the curve. Costs per node for integrated-services-digital-network connections should wind up lower than costs for token-ring, token-passing, Ethernet, or Cheapernet by 1988.

At the Dallas forum, AMD previewed its four initial ISDN interface circuits, targeted at the four-wire S ports for terminals in a private branch exchange as currently defined by the CCITT. The S interface is one of four equipment connection points being eyed by chip makers as potential ISDN interface products.

Two CMOS chips—the Am79C30 digital subscriber controller and the 79C311 digital exchange controller—provide access to the CCITT-proposed protocols. The bipolar 7936 subscriber power controller and 7938 quad exchange power controller are intended to supply stable power to the interfaces. Ruebusch says that AMD intends to be one of the first companies to offer fully ISDN-compatible S interfaces in the second half of the year.

"We believe 1985 will be the year that [ISDN system] prototypes are being built and silicon samples are made available," Ruebusch predicts. "Then, 1986 will be the year that [the system] goes into production." AMD estimates that in two years the availability of silicon interfaces will drive ISDN connection costs below the average cost of local-area networks (see chart).

But just across town, Motorola Inc. telecommunications chip managers—planning the introduction of a competing S transceiver two years from now—strongly differ with forecasts of quick, widespread ISDN use. "ISDN is clearly a direction everyone is wanting to go," notes Al Mouton, MOS telecommunications marketing manager.

"The question is—how is it going to be implemented and what standards are going to be used? Most vendors that I talked to say plainly they have got problems with costs of the four-wire ISDN interface. They are fighting to cut out every little cent in phones today.

"So, we believe we'll end up with PBX networks that mostly use custom transmission schemes that are low cost and optimized for applications. These will then play with a few S-compatible terminals where customers need a global interface."

U-turn. Instead of the strictly defined S interface, Motorola—like other chip makers—is placing its digital telecom emphasis on the ISDN U interface, which is still undefined by the CCITT and generally aimed at the central-office-to-subscriber termination points.

Motorola believes that the U interface will be the vehicle for proprietary PBX interfaces as well. The company's MC145422 and 145426 universal digital-loop transceivers (UDLT) are now available for 80-kb/s full-duplex communications over twisted-pair wire.

The UDLT-2, now under development, will be introduced in early 1986 for 160-kb/s user-definable transmission schemes. And the UDLT-3 will employ echo-canceling adaptive equalization for multiplexing over longer loop lengths of 3 to 5 km. Motorola's first UDLTs use a simpler time-division multiplexing known as ping-pong.

Intel Corp. telecom-circuit officials plan to pursue both two-wire U and four-wire S interfaces with new CMOS chips. Intel's 29C53 will serve the standard S interface; the 29C55 will be aimed at the two-wire U interfaces.

"In a large PBX, we believe the marketplace is requiring a two-wire transceiver with capabilities in the 3-km range," says Pat Weston, technical marketing manager. "We see large systems using two-wire from PBX to a cluster, and then two- to four-wire conversions from there."

However, Intel says that two-wire PBX interfaces—even though they are not yet defined by the CCITT—will not be proprietary, says Graham Alcott, Intel's telecom operations manager. "ISDN could be as significant to the office-communications marketplace as personal computers have been in the office-productivity and data-processing segments."

At Mitel Semiconductor, Kanata, Ont., Canada, the movement toward ISDN is already bringing in revenue, says John Freeman, vice president of marketing. Mitel sold about $5 million worth of chips—mostly MT8975 and MT8978 digital trunk circuits—for ISDN-compatible communications. The firm is also marketing a line of serial digital circuits for U interfaces to ISDN systems.

American Microsystems Inc. will second-source the MT8980 line of digital interfaces. Mitel is also developing a four-wire S transceiver.

Pulsing the market. Harris Corp.'s Semiconductor Sector, in Melbourne, Fla., is working on a U-like two-wire transceiver, called HC5590, which is expected to be introduced by early next year. "If you are following the blitzkrieg product developments and you get numbers from three or so guaranteed-type customers, you can come up with a part that is generally acceptable if you continue to pulse the rest of the market," says William J. Bahr, Harris's telecom product-line marketing manager.

National Semiconductor Corp. will introduce a two-wire U interface by the end of the year. But the firm is continuing to monitor ISDN demand before announcing any dedicated products, says François Crepin, director of telecom market development. "We have been doing a lot of work in the area to be ready, but we are still waiting for the standards to be set," he adds.

Texas Instruments Inc.—which recently shifted its telecom-circuit operation from Dallas and placed it under the Programmable Products Division, in Houston—is not planning to introduce any ISDN products this year. But the company believes the new telephony standard will create business for its TMS320 digital signal processor. "What we are working on here are the engines for ISDN systems," says Michael Ames, marketing manager for the firm's TMS320 line. □

MAINFRAMES

BURROUGHS, HONEYWELL JOIN IBM's SIERRA CLUB

New York

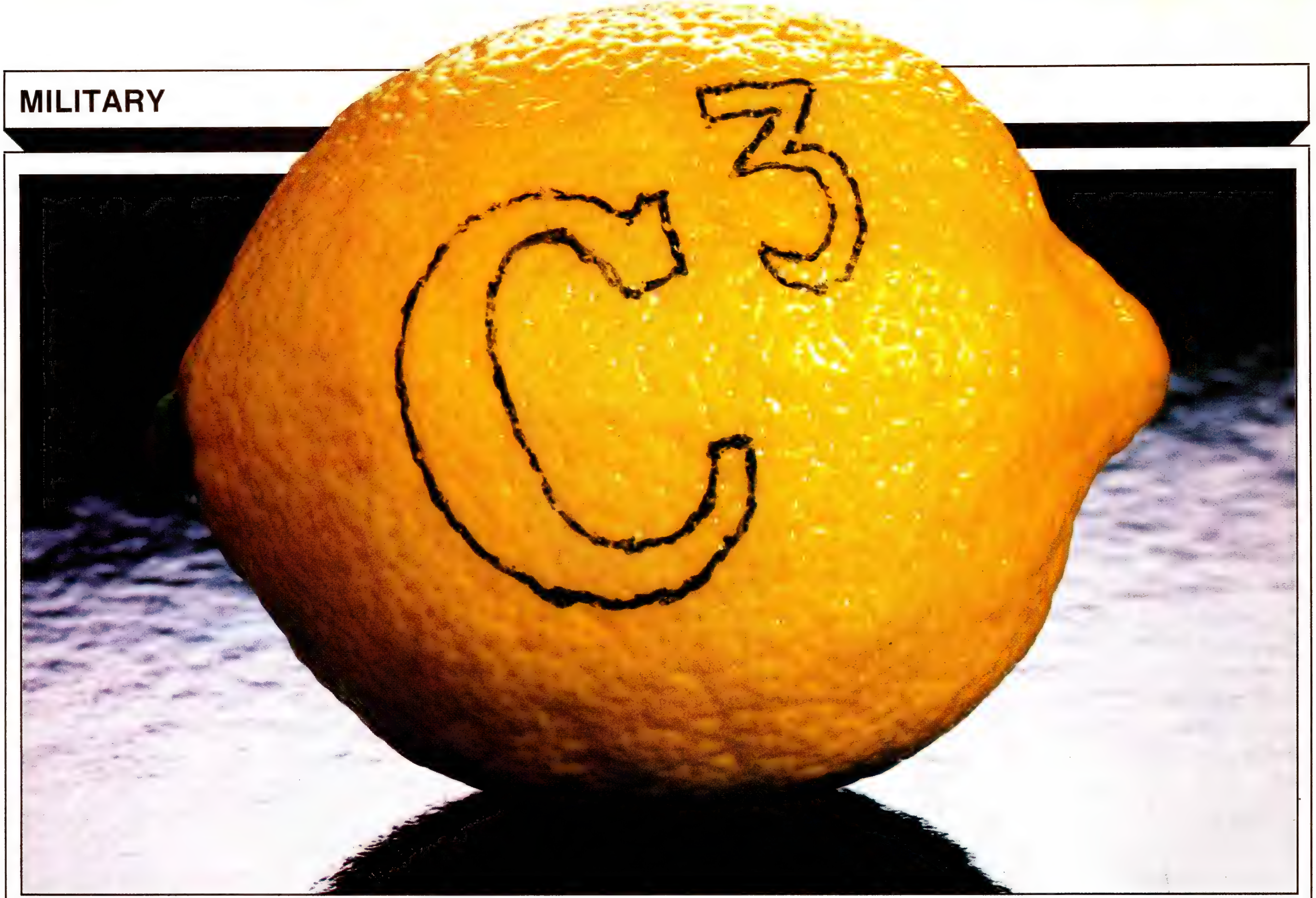
Burroughs and Honeywell last week became the newest members of the Sierra club, joining NEC, Hitachi, and National Advanced Systems as vendors with products that match the performance of IBM Corp.'s new top-of-the-line 3090 (Sierra) processors.

Burroughs Corp. unveiled its A 15 series, which get its high-speed performance from the use of 1,200-gate emitter-coupled-logic arrays from Motorola Inc., as well as from 256-K dynamic random-access-memory chips made in Japan. Honeywell Inc. adapted the ACOS 1000 processor manufactured by its Japanese partner, NEC Corp., with Honeywell-developed current-mode-logic technology to top out its mainframe line with the DPS 90 series. Honeywell also uses 256-K DRAM chips.

Burroughs offers eight models of the A 15—a single-processor model, three dual-processor versions, and two models in the heady triple- and quadruple-processor milieu. One model in each of the two- to four-processor versions comes with a system-partitioning option with which a system can be broken into two or more smaller ones.

Burroughs's A 15 four-processor models M and N will be available by the second quarter of 1986, a full year ahead of IBM's four-processor 3090 model 400. Deliveries of Burroughs's entry-level single-processor version will begin in the third quarter of 1985. Prices for the A 15 family of processors range from $2.9 million to more than $6 million.

Honeywell unveiled five models of the DPS 90—in configurations of one to four processors, plus an additional two-processor model that offers full redundancy. System prices fall in the range from $3.95 million to $8.35 million. –**Tom Manuel**



STRATEGIC C^3
MORE IS LESS

Megabuck upgrades emphasize technology, but experts warn that the system remains vulnerable to nuclear knockout ☐ *by Alexander Wolfe*

New York

"Reach out and touch someone." That might have been a pitch for the nation's strategic command, control, and communications system, which is supposed to enable top military commanders to keep in touch with hundreds of bases and installations and hundreds of thousands of troops around the world. But today, in spite of the billions of dollars pouring into technology-intensive upgrades of the C^3 system, experts are saying it sounds more like "Sorry, wrong number."

Though reports of problems have surfaced regularly over the years in scientific and news publications, this time around there is a heightened sense of urgency. "What's new today is that all the old [problems] have been happening for so long incrementally that the dimension of the problem is far greater today," says Paul Bracken, associate professor at Yale University's School of Organization and Management and author of *Command and Control of Nuclear Forces*.

"We've never gotten out of any command and control system 10 cents on the dollar in utility," says retired admiral Eugene J. Carroll, now deputy director of the Center for Defense Information, a Washington think tank. "We're trying to build a perfect system. In historical terms, this has never worked."

Most telling may be the criticisms voiced by Bruce Blair, author of a classified report prepared for the congressionally funded Office of Technology Assessment. Blair, a former Minuteman missile launch officer, currently holds a security clearance as an employee of the Defense Department's Defense Communications Agency.

At a Washington press conference last November, he said, "A strong case can be made that deficiencies in our nuclear-control system have been so severe for so long" that everything else pales by comparison.

The DOD, as part of the current cycle, will spend upward of $1 billion on C^3 in 1985, according to estimates. The new procurements will add to a system already so sophisticated and complex that it is often referred to as the military's "central nervous system."

Crucial programs. The success of the effort to modernize C^3 to manage nuclear-age military forces hinges on two programs. A revamping of the World-Wide Military Command and Control System, a kind of military Bell system, is just getting under way. Work on the long-awaited Military Strategic, Tactical, and Relay (Milstar) satellite communications system continues. Deployment is set for the early 1990s.

WWMCCS (pronounced Wimex) is at the hub of the wide-ranging information-transfer net that is C^3. In simplest terms, WWMCCS routes raw information—on troop strength and supplies, for example—up the chain of command, and funnels individually keyed detailed orders and massaged data back down to thousands of military installations.

More importantly, during a crisis (nuclear war is the ultimate example), WWMCCS must support communications for the president and coordinate retaliation.

Established in 1962 by President Kennedy, the system was seen as the answer to the problems experienced with real-time information gathering during the Cuban missile crisis. WWMCCS soon evolved into a nonstandardized jumble of computers, however, and ended up compiling a less-than-sterling track record. In 1967, a warning message reportedly failed to reach the U.S.S. Liberty prior to an attack from Israeli gunboats. Likewise, a message to the U.S.S. Pueblo, seized by North Korea in 1968, was misrouted.

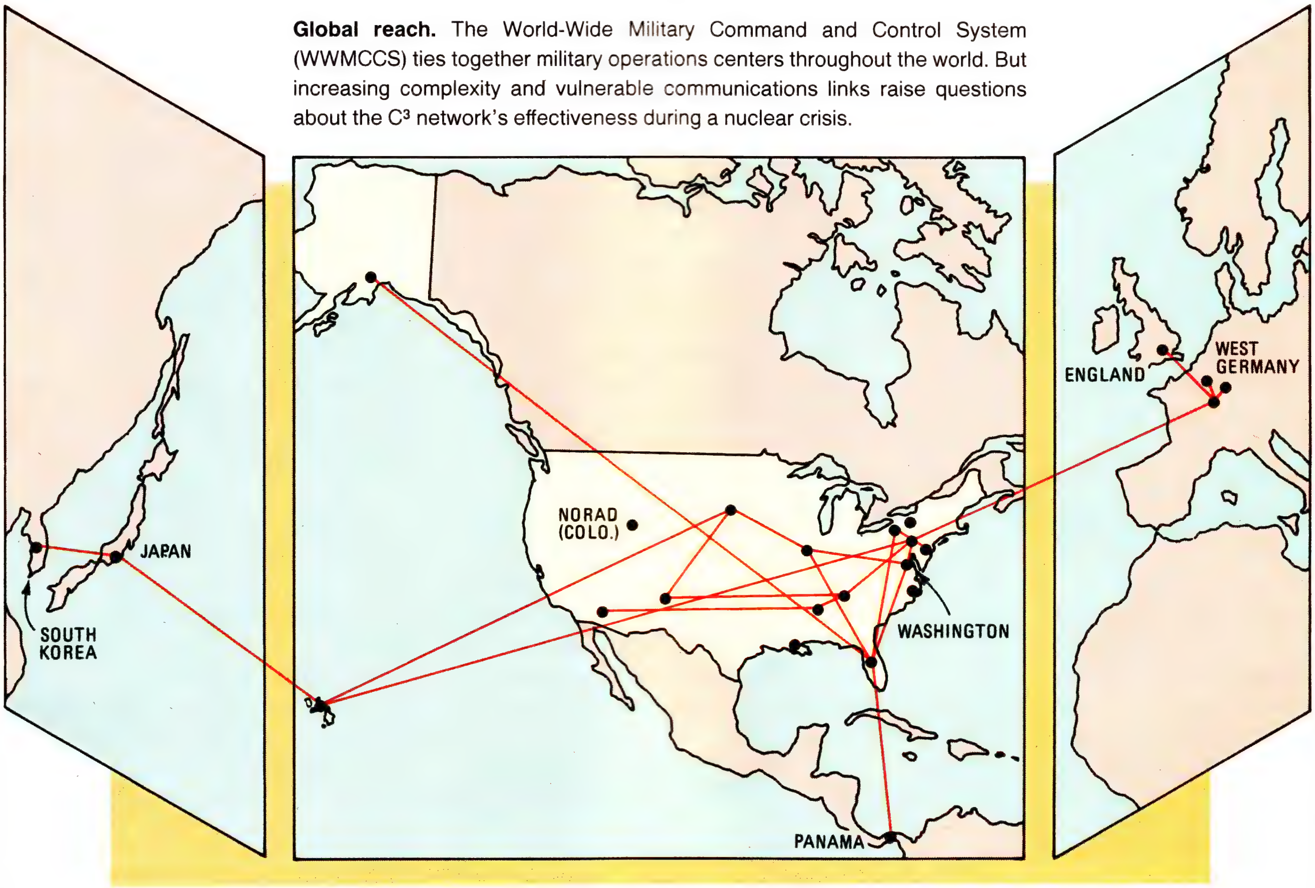
In 1971, WWMCCS was reorganized and the Pentagon tried to consolidate its functions. Today, 60 different satellite, radio, and land-line communications systems are tied into 27 command centers throughout the world (see figure). Controlling the operation are 35 batch-era Honeywell Series 6000 computers, running 20 million lines of Cobol.

But, according to a well-placed industry source, serious unacknowledged technical problems with WWMCCS remain, and it has developed an appetite for computer downtime. In the most highly publicized incident to date, a nuclear alert was generated when a war-games program wound its way on line at the North American Air Defense System headquarters, the attack warning nerve center in Colorado.

And during 1977 system-wide exercises, code-named Prime Target, attempts to send messages between commands and obtain information from WWMCCS were unsuccessful more often than not. Prime Target's failure rate exceeded 60%.

DOD to the defense. Despite these horror stories, DOD officials have said that reports of the system's deficiencies have been greatly exaggerated. Still, the high-profile statements of the Reagan administration stressing the importance of C^3 indicate that it is eager to add improvements, however perfect the DOD claims the system is.

Donald C. Latham, assistant secretary of defense for C^3, was unavailable to discuss WWMCCS's problems with *ElectronicsWeek*. His office instead provided documents de-



Global reach. The World-Wide Military Command and Control System (WWMCCS) ties together military operations centers throughout the world. But increasing complexity and vulnerable communications links raise questions about the C^3 network's effectiveness during a nuclear crisis.

scribing the C^3 programs for fiscal year 1986.

Propelled by the obsolescence of its data-processing equipment, a new round of WWMCCS upgrades—expected to run to $500 million—is under way. A first-phase $27 million contract, let in October 1983, was awarded to GTE Government Systems Corp.

Initial work involves planning the transition of new technology into WWMCCS. "The criticisms of the system have [concerned] the timeliness of the data, the accuracy of the data," notes Lewis Hadelman, GTE's executive program manager. "Our key issue is upgrading performance."

According to Hadelman, improved software—the outcome of a large-scale Ada development effort—will include user-interactive features.

Sore point. WWMCCS's cumbersome data base has always been a sore point. To determine the number of planes at Edwards Air Force Base, for example, a user must wade through mammoth logistical printouts. With the projected improvements, the system will be able to pull out numbers quickly, in response to a commander's request.

GTE will also buy new computers. Message delivery, from central nodes to remote users further down the command chain, will be fully automated through local-area networks.

The Pentagon hopes that the current upgrade will address the dilemma of underpowered hardware and overblown software. Indeed, the Air Force has even given this latest system incarnation a more streamlined name: WIS, for WWMCCS Information System.

But most observers take a jaundiced view of promised cures. "We've been about to solve the problems in WWMCCS every year for the past 10 years," says Carroll, of the Center for Defense Information. Counters GTE's Hadelman, "We're going to be able to give [WWMCCS users] the data they need in a timely fashion."

On the air. Though WIS may sound clean on paper, real-world message transfer depends on a vast, hard-to-manage communications infrastructure. To route a message, the WWMCCS software can choose from any of over 40 different telecommunications networks.

Currently, most wideband (that is, voice and data) message traffic is carried by the Defense Satellite Communications System. But there are channel-capacity shortfalls in the system, and the DOD makes up the difference with leased space on commercial satellites.

Milstar, the centerpiece of today's program of command-system modernization, should fix the problem. Spending on the program will average $400 million per year for the rest of the decade. At least seven contractors—Lockheed, TRW, Hughes, Raytheon, GE, Ford Aerospace, and GTE—are currently on board.

Primarily, though, Milstar is an important factor in planning for a nuclear war. Most of today's communications systems will be useless in a nuclear war. Some will be knocked out by direct attacks—this is called decapitation to C^3. Others may be subject to jamming. Most will fail because of the high-altitude electromagnetic pulse that is unleashed by nuclear explosions. EMP's high-energy surge voltage blows out integrated circuits and transistors.

Enter Milstar. According to DOD documents, Milstar will "ensure effective, continuous control of strategic forces both during and after a nuclear attack." This means it will ensure communication between the president and top military commanders.

In terms of design, therefore, Milstar is shooting for survivability. At Washington's National Defense University last November, the DOD's Latham said, "Every effort will be made to ensure that the system provides both survivability and endurance by use of on-board processing, cross banding, crosslinks, common modulation, interoperability, hardening, and autonomy."

Not invincible. There may be some chinks in Milstar's technological armor, however. Nuclear blasts, Blair reports, will "degrade communications severely for hours, over very large areas." He also notes that Milstar could be hit easily by future Soviet antisatellite weapons.

COMMAND, CONTROL, AND COMMUNICATIONS SYSTEM
BUDGET ESTIMATES (SELECTED PROGRAMS)
(millions of dollars)

Program	1985	1986	1987
World-Wide Military Command and Control System			
Systems Engineering	30.6	29.0	27.0
Data Processing	1.5	0	0
Architecture	11.0	10.5	11.0
WWMCCS Information System	89.3	155.0	195.0
Total	132.4	194.5	233.0
Minimum Essential Emergency Communications Network			
Defense Communications Agency	15.2	15.9	16.0
Air Force	116.9	145.0	120.0
Navy	1.5	1.7	2.0
Total	133.6	162.6	138.0
Milstar	325.0	340.0	400.0

SOURCE: FROST & SULLIVAN INC.

"Imagine what happens when you get into wartime with EMP," says Carroll. "It's impossible to imagine [C^3] functioning properly in a war."

Regardless of whether C^3 can actually function during a nuclear war, Blair says that its prewar vulnerability has a dangerous destabilizing effect: "Decapitation has become the most significant threat to U.S. nuclear capability."

Decapitation, or knockout, is a real possibility because of the "gross disparity between the number of significant [C^3] control nodes and the number of Soviet nuclear weapons available for use against them."

And because the Soviets may think they can wipe out a nonhardened, nonresistant C^3 system, the U.S. may develop a hair-trigger mentality in a crisis. "The vulnerability of our control systems long ago created a bias in our national command system toward rapid and early execution of the SIOP [Single Integrated Operational Plan—the retaliatory launch sequence], while the system was still intact."

Likely to remain a powerful deterrent, however, is the communications system of last resort. Known as MEECN, for Minimum Essential Emergency Communications Network, this system has a highly survivable, very low-frequency ground-wave channel.

Vlf, however, supports only slow-speed low-data-rate communication. Thus MEECN is basically geared for sending go-code retaliatory missile-launch instructions after all other possible strategic and tactical alternatives have been exhausted.

The Soviets, however, may be in no better shape. Looking at the Russian side of the nuclear equation, "I think they have basically the same problems we have," says Bracken. Their system is somewhat more centralized than the U.S. system and less technically oriented, relying more on human agents to provide information on missiles in Europe, for example.

Currently, in the era of integration, they are learning how to tie together and effectively use their far-flung systems. Bracken sees the Soviets hampered by oversecrecy, an outgrowth of the rigidity of their society. Problems that do occur don't get reported up the chain of command, for fear of punishment. The Soviets have a cover-their-mis-takes mentality, he says.

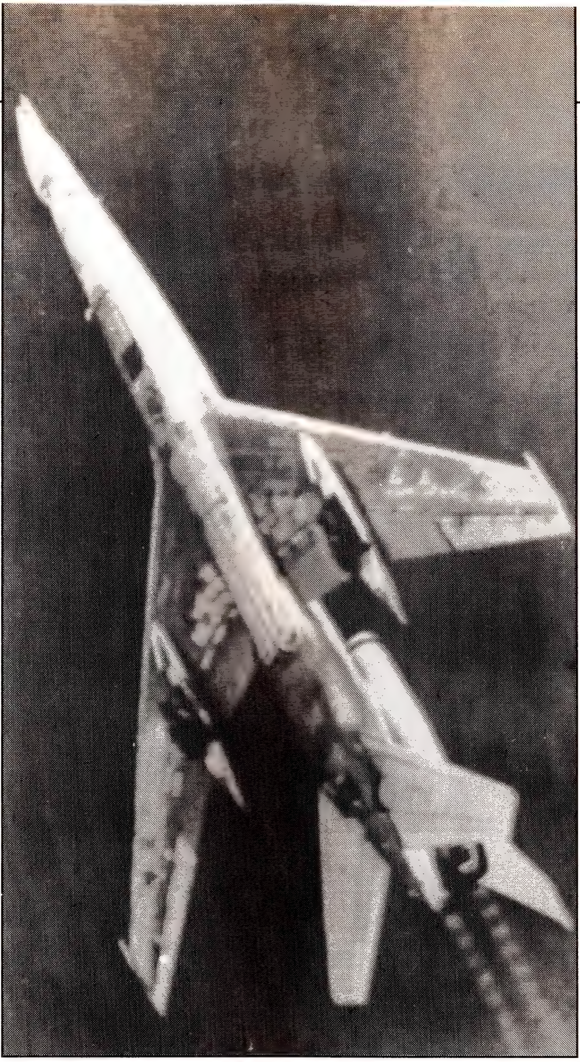
Problems in the Soviet command and control chain were perhaps nowhere more evident than during the infamous incident of August 1983 involving Korean Air Lines Flight 007. As recounted, a KAL 747 jetliner, en route from Alaska to Seoul, wandered off course. The jet flew in Soviet airspace for over two hours before being shot down by Russian MiG interceptors.

The fact that the plane was undetected for an extended period before any Russian attempts to intercept it points up deficiencies in the Soviets' radar tracking setups. Also questionable was the coordination of communications—which is the real key to command and control—between the different tracking stations and the fighter commands.

Though high technology may be seen as the savior by both the U.S. and Soviet military establishments, new technology as the answer to C^3 problems is falling from favor in one quarter. A new thrust from a dispersed group of military thinkers is advocating a broader-ranging analysis. "The actual reasons [for C^3 problems] have been much more subtle" than simple technology, says Yale's Bracken.

Rigid fashion. John Boyd, a retired Air Force colonel, eschews the emphasis on computers and satellites, saying "Conversation should stay ahead of fast-paced events," not vice versa. Boyd sees a C^3 system striving to deliver increasingly complex and compartmentalized messages in a rigid fashion. Current C^3 system design hinders interaction with the external environment, he says.

In fact, a Catch-22 of command and control exists as applied to a multilayered military command structure. For different levels to communicate, complicated checklists and interfaces are necessary. Yet it is this same C^3-by-numbers approach that hinders quick response during wartime.



Red menace. The U.S.'s C^3 system is designed to coordinate a response to a Soviet nuclear incursion from Backfire bombers (left) and ballistic and cruise missiles.

More in tune with real-world battle scenarios would be a C^3 setup based on flexibility and adaptation. Boyd points to the book *In Search of Excellence*, written by Thomas J. Peters and Robert H. Waterman Jr. (Warner Books Inc., 1982), as one model for effective teamwork that, perhaps surprisingly, can be applied to the military framework.

Indeed, many agree with Bracken's remark that "deficiencies have focused mainly on technical problems. The actual reasons have been much more subtle." Such terms as "organizational framework," "human factors," and "ambiguities" are mentioned by many who emphasize that C^3 does not live by technology alone.

In lieu of ideas that, while interesting, are unlikely to have significant near-term impact, some immediate solutions to the C^3 gap are offered. Blair proposes spending an additional $30 billion to $50 billion to set up survivable command posts, probably on submarines. This would improve deterrence by buttressing the U.S. military's ability to respond to a Soviet attack.

Latham and the DOD point to Milstar and the multiyear high-priority push to upgrade C^3 capabilities as the solution to some of the most pressing problems, if admittedly not all of them.

But Bracken, who is pleased to see increased spending in C^3 ("You take what you can get," he has said), still laments, "We're playing catch-up ball in the sense that our ability to command our forces has gone down considerably in the past 15 years."

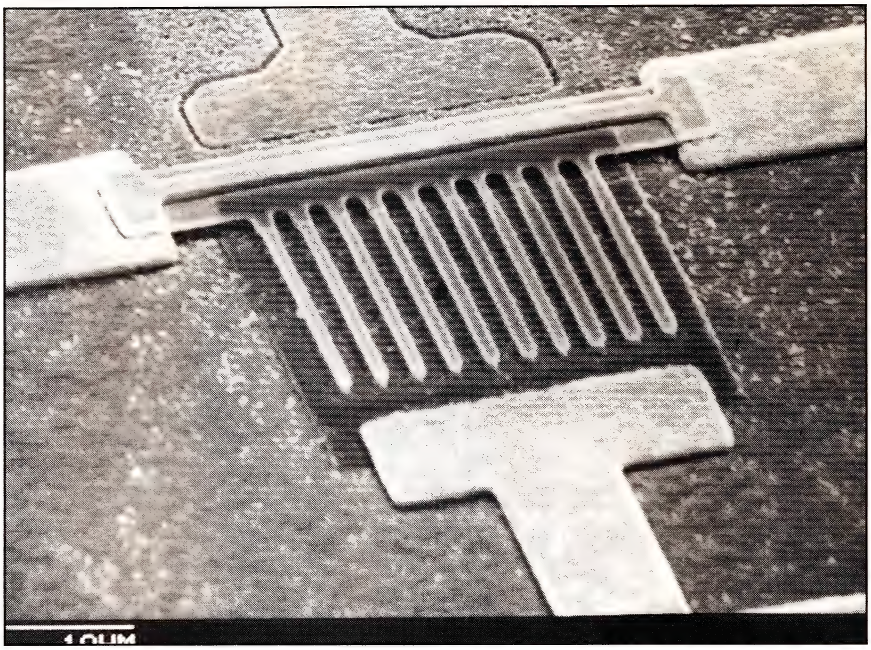
And Blair states, "Underneath the encouraging rhetoric, however, lies the sobering reality that we are not much closer to answers to the central command questions than we were a decade ago." ☐

BALLISTIC TRANSISTORS FASTEST YET

Palo Alto

How fast a transistor might be is a crucial question in semiconductor research. One answer surfaced in mid-March, as Cornell University's School of Electrical Engineering celebrated the centennial of its first graduates with a symposium on the future of microelectronics, held here at Stanford University.

Gallium arsenide ballistic transistors will cut switching times to around 1.5 ps in about three years, says Cornell professor Lester Eastman. That is so fast that a massive effort in computer architectures will be needed to take advantage of the speed. Eastman believes "the supercomputer of today will be the desktop calculator of tomorrow." He also expects dramatic advances in microwave communications, with satellites operating in the 94-MHz region, where absorption of signals is at a minimum.



Straight up. Switching speeds of nearly 1 ps are envisioned for ballistic-injection vertical FETs. The gallium arsenide device was fabricated at Cornell University.

Eastman is one of a small coterie of physicists around the world that has been working for some time on ballistic transistors, in which electrons travel at speeds up to six times faster than they can in conventional silicon structures. The increase stems partly from the inherently faster transit time of GaAs material and partly from the travel paths, which are so small that there are almost no collisions to slow down electrons.

Like a dropped rock. As a result, the electrons pick up speed as they travel, "just as a rock dropped from a bridge increases in velocity," Eastman says. His group at Cornell expects to make the transistors even faster by injecting electrons into them (see "The growing field of shrinking structures," p. 23).

Eastman and his colleagues have been working for the last seven years on the concept of ballistic transistors at Cornell's National Research and Resource Facility for Submicron Structures. The facility is on the verge of building a GaAs ballistic transistor.

Another organization investigating the concept is AT&T Bell Laboratories, where work aimed at fabricating ballistic transistors in silicon is under way. At last week's annual meeting of the American Physical Society in Baltimore, Bell Labs researchers presented an updated version of an earlier paper on electron movements in single-crystal thin metallic films.

"If Bell can make complete molecular-beam-epitaxy structures on silicon, then they will have a way of getting down to a smaller scale [necessary for ballistic transistors]," explains Peter Price, a semiconductor physicist at IBM Corp.'s Thomas J. Watson Research Laboratories in Yorktown Heights, N.Y.

In France, the Centre National d'Etudes des Télécommunications has already found a way. Its Microelectronics Research Center in Grenoble has fabricated an ultrafast transistor that employs a silicon-metal-silicon structure [*ElectronicsWeek,* Oct. 8, 1984, p. 20].

In the CNET structure, a thin layer of cobalt disilicide is sandwiched between two layers of silicon. The $CoSi_2$, which serves as the transistor's base, is so thin that electrons move across it with speeds that make possible a theoretical cutoff frequency of 30 GHz.

As for IBM, it has had work going on in ballistic transistors since the early 1980s. But Mordehai Heiblum and Marshall Nathan, who are leading the effort, say that IBM has not yet actually made anything small enough to be called a ballistic transistor. They have made partial structures of a tunneling hot-electron transistor, a device that has two sets of carriers. But the electrons are hot and cold, meaning ballistic and nonballistic. "There isn't any reason why we can't make one. We just haven't," says Nathan.

Other avenues. "Right now, all over the world, there are only about 20 people working in the area of ballistic transistors," says IBM's Heiblum. But, he adds, there are probably several hundred electrical engineers and physicists working on more conventional devices that include the GaAs metal-semiconductor FET, submicron MES FETs, and what IBM calls MOD FET (better known as the HEMT, for high-electron-mobility transistor), and to a lesser extent on the heterojunction bipolar

The growing field of shrinking structures

Much of the pioneering work on the concept of ballistic transistors has been done at the National Research and Resource Facility for Submicron Structures (NRRFSS) at Cornell University. Established by the National Science Foundation in 1977 to foster research in submicron fabrication technology, the NRRFSS provides facilities for about 200 researchers, including 53 faculty members from Cornell and other universities, 12 scientists from industry and government, and more than 100 graduate students.

Heavyweights such as IBM, AT&T Bell Laboratories, and General Electric are among the 40 industrial sponsors, joined by such government affiliates as the Lawrence Livermore and Los Alamos national laboratories. These sponsors help Cornell provide 40% of NRRFSS funding; NSF puts up the other 60%. According to NRRFSS director Edward D. Wolf, a professor of electrical engineering at Cornell, $23 million has been invested in the facility over the past seven years. Its current annual budget is $2.2 million.

Joel Wendt, a 25-year-old PhD candidate in electrical engineering working with Cornell professor Lester Eastman, is part of the effort to move ballistic transistors from the conceptual to the device stage. Wendt is attempting to fabricate vertical FETs that employ ballistic electron injection, or launching. The process involves sending electrons across the discontinuous band gap created by the layering of aluminum gallium arsenide and GaAs. Because AlGaAs possesses a larger band gap, explains Wendt, the resulting discontinuity provides "a step in potential" that is picked up by AlGaAs electrons as kinetic energy. Transit times as low as 1 ps have been sustained over a maximum distance of ½ μm, he adds. **–George Leopold**

transistor. "The projections are that the MOD FET and the bipolar devices may have switching times as fast as 5 ps."

Another fundamental approach is quantum tunneling, a method defined by Nobel Prize winner Leo Esaki of IBM, Kang Wang of the University of California at Los Angeles, and others. **–Merja Lehtinen**

TELECOMMUNICATIONS

PACIFIC BELL OFFERS MISSING LINK TO USERS

Palo Alto

Pacific Bell of San Francisco, one of the regulated Bell operating companies, has filed for patents on a technology that could provide the missing link between the 64-kb switched digital network and the subscriber's premises.

PacBell says its technology, which it calls Victoria, will permit two voice conversations and five data channels—one at 9,600 baud and four at 1,200 baud—to be digitized and carried simultaneously over a single two-wire telephone line. PacBell will test a system using the method in California this year in cooperation with Apple Computer Inc.

Similar systems, developed to interface with private branch exchanges, were described at the Institute of Electrical and Electronics Engineers' 1985 International Solid-State Circuits Conference in February by Mitel Corp. and several other telecommunications firms. PacBell's system, however, is for home and small-business use over the 9,600-baud line to packet-switched networks and at 1,200 baud for dedicated lines to private services.

The system will require new hardware, which PacBell cannot legally make because of the stipulations made when the operating compa were split off from AT&T. The company would not disclose where it expects to get the multiplexing equipment or the chips to permit high-bandwidth transmission over 4-kHz phone lines—or even what the bandwidth of the system would be. Presumably, the system uses some kind of data compression to pack all its digital signals into the 64-kb bandwidth of the integrated services digital network.

"One of the key concepts of ISDN is the presentation of digital signals to the customer," said Thomas C. Edrington, PacBell's assistant vice president of technology assessment and planning. "The digital signal is what makes possible the end-to-end [error-correcting] aspects of ISDN technology."

The new technology provides a digital pipe to a packet network or to another computer, explains Jill Lander, Victoria project manager. One of the 1,200-baud channels, for instance, could have a direct line to the computer at a security-alarm firm. Bell sees meter reading, electronic banking and shopping, and videotext as other possible applications.

PacBell says the system works transparently with standard telephones and any central office switch. Some kind of demultiplexing and echo-canceling equipment is required at the central office, but the company declines to explain this or any other aspect of the technology. Nor will it estimate the cost of the home multiplexer or of its digital service.

Full testing. Although PacBell says it has already field-tested a prototype system, it will work with Apple to develop the equipment for a full-scale test later this year.

"We want to leverage-off their service," said Peter Hirschberg, head of information services for Apple's new technology group. "Currently, people have to make a deliberate decision to use a dial-up service. The Victoria technology makes it possible for services to call into the home."

Apple is at present focusing on home-banking applications for the Apple II and the Macintosh. It plans further services in home shopping and videotext. Lander said that PacBell would also work with other computer vendors once the service is established. **–Clifford Barney**

GaAs WAITS IN THE WINGS

Lured by the billion-dollar potential of the digital-IC market, manufacturers slowly gear up—and keep their fingers crossed ☐ *by Larry Waller*

Los Angeles

For a business selling only some $75 million of product yearly—and two thirds of that to low-volume military users—gallium arsenide semiconductors exert what appears to be an irresistible attraction. Companies already on the scene continue to increase investments, and heavily staked startups keep popping up like weeds in spring. In recent weeks, a major new player, Ford Microelectronics Inc., has made the plunge with a $33 million plant in Colorado Springs to manufacture advanced integrated circuits.

The long-term attraction, of course, comes from GaAs digital ICs (see "Not sexy, but still a star," p. 25), which some industry participants predict will reach the billion-dollar mark by the 1990s—although how large the numbers will get remains one of the puzzles that has stumped GaAs watchers for years. Market researchers tend to expect greater growth than that; manufacturers lean toward more conservative figures.

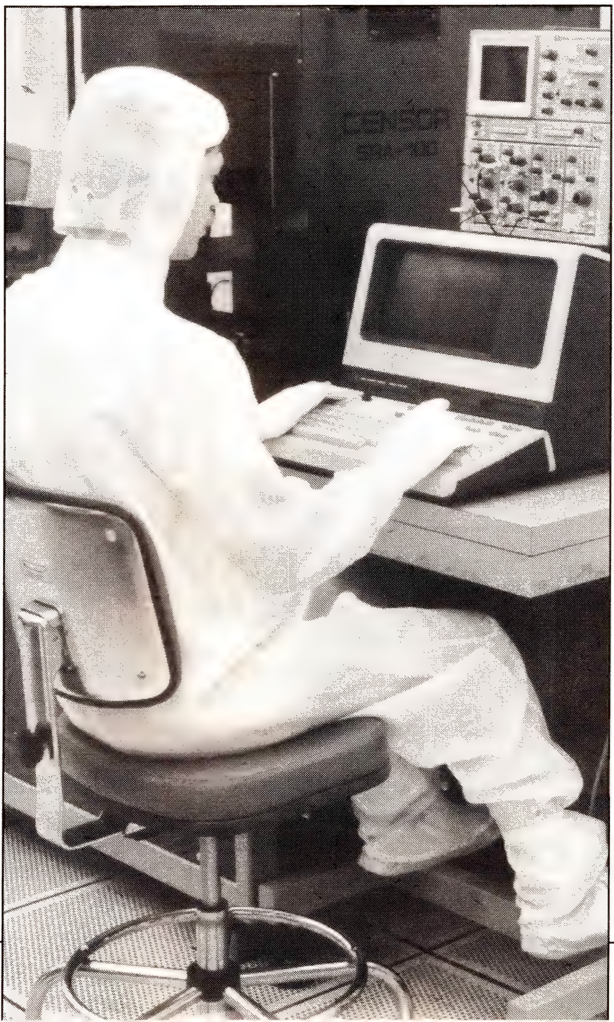
Predicting the future aside, nascent GaAs operations nationwide have made real strides during the past nine months—a period that could well mark the beginning of a commercial business in GaAs semiconductors [*Electronics,* June 14, 1984, p. 101]. For the first time, interested customers are taking seriously the suppliers that are tooling up products for them.

For example, at Gigabit Logic Inc., discussions with customers about the Newbury Park, Calif., firm's 12-member family of fast GaAs logic—announced last June—eventually get around to production questions, says Anthony R. Livingston, vice president for marketing. GaAs is moving through a stage where "users want to see your plant, put their hands on product, and verify you're actually making it."

Put up or shut up. The necessity of dealing with such basics—which are taken for granted with silicon—is a holdover from too many pie-in-the-sky promises about GaAs products made in the past during periodic booms in interest for the material. Before any big production orders ensue, realistic answers have to be provided to users.

Keen interest in GaAs products is developing, surpassing even the rosy market predictions of a year ago, *ElectronicsWeek* has found. At TriQuint Semiconductor Inc., the GaAs foundry newly spun off by Tektronix Inc., president Al Patz says nonmilitary business has surged in the last couple of months.

Patz now has more than 20 customers for the Beaverton, Ore., foundry—two thirds of them commercial. His reason: "Telecommunications is heating up faster than anybody expected," particularly in parts for fi-



Before the storm. Clean rooms, such as Gigabit Logic's GaAs IC fabrication facility in Newbury Park, Calif., will see a lot more activity in the years ahead.

ber-optic linkage. Shipping product since October, the operation has gone so well that TriQuint will add large-scale-integration gate arrays late in the year, along with some generic IC and analog parts.

Also reporting a significant proportion of nonmilitary customers is Harris Microwave Semiconductor Inc. Its digital ICs are being designed into communications and test equipment. Harris claims to have sold the first such GaAs parts in early 1984.

All the companies *ElectronicsWeek* surveyed noted that current sales activity is largely for evaluation quantities. "The commercial designs are several years away from [production] volumes," says Robert M. Rogers, GaAs marketing manager at Honeywell Inc.'s Richardson, Texas, plant. But getting a share of design-ins now is important "to position ourselves for when it [volume] hits," he adds.

Honeywell will operate a 3-in.-wafer fabrication line for the Defense Advanced Research Projects Agency. The firm offers its own gate arrays, including a 432-gate unit and a multiproject test chip that allows several customers to share a single wafer for experimental designs [*Electronics,* April 19, 1984, p. 50].

Which comes first? Getting up to volume manufacturing levels and lowering the cost of materials are prerequisites for turning a GaAs profit. This can lead to the classic chicken-or-egg quandary, says Michael Ledford, vice president of marketing at Ford Microelectronics. The company is a subsidiary of Ford Motor Co., formed to allow automotive and aerospace engineers to design their own chips and to coordinate Ford semiconductor buying. Achieving volume first, he says, "will make the cost of devices significantly less."

The major barrier to lowering costs remains the GaAs itself. The material's price has not changed appreciably from the $170-per-wafer range of a year ago. What has changed is quality, or the number of imperfections per wafer. It is getting better for the same price, says Larry Eslinger, director of marketing at Ethyl Corp.'s Morgan Semiconductor Division. Morgan says more experience and improved equipment underlie the quality advance.

But no price breakthrough will come soon, says Eslinger—not for at least two or three years. "But that's with one proviso—we have no idea what the Japanese might do." In Japan, about 14 GaAs material suppliers are battling for market share, which could lead to dumping in the U.S. at lower prices, he explains.

At present, the material's cost is some 20 times that of silicon—far too high to be competitive for most applications. Ford Microelectronics' Ledford thinks that, given much lower material prices, "there is no reason why GaAs cannot be only two to four times more expensive than silicon circuits. Cost of manufacturing is no more than any other fine-line geometry process."

No problem. Reflecting the view of most GaAs experts, Ledford plays down any technology difficulties. "The question of whether the technology is doable is pretty much behind us now," he says. At this point, GaAs is far enough along to profit from advances in silicon processing, including direct step-on printing photolithography and 1-μm etching systems, which Ford will be using.

First working samples, by year end, will be semicustom circuits—both gate arrays and standard cells. Standard products, notably memories, are under consideration. The big challenge, as with silicon, is to improve yields and develop a repeatable process, adds Ledford.

Tough market. The prospect of tough competition, together with the high cost of entry, does not deter GaAs entrepreneurs with a different concept. The newest kid on the block is Vitesse Electronics Corp., Camarillo, Calif., which is backed by $30 million from diversified manufacturer Norton Co. (The $30 million level seems to be the stake required to play in the GaAs game. Gigabit Logic recently completed a new round of financing, bringing its investment to approximately this figure.)

Vitesse's approach is to "leverage LSI silicon technology into gallium arsenide," notes Alfred S. Joseph, the firm's president. Initially, the company plans to design and market silicon circuits and high-speed computers by early 1986, then follow with both custom and standard GaAs chips. He hopes to have fabrication going by late summer.

Venture capitalists are still skittish

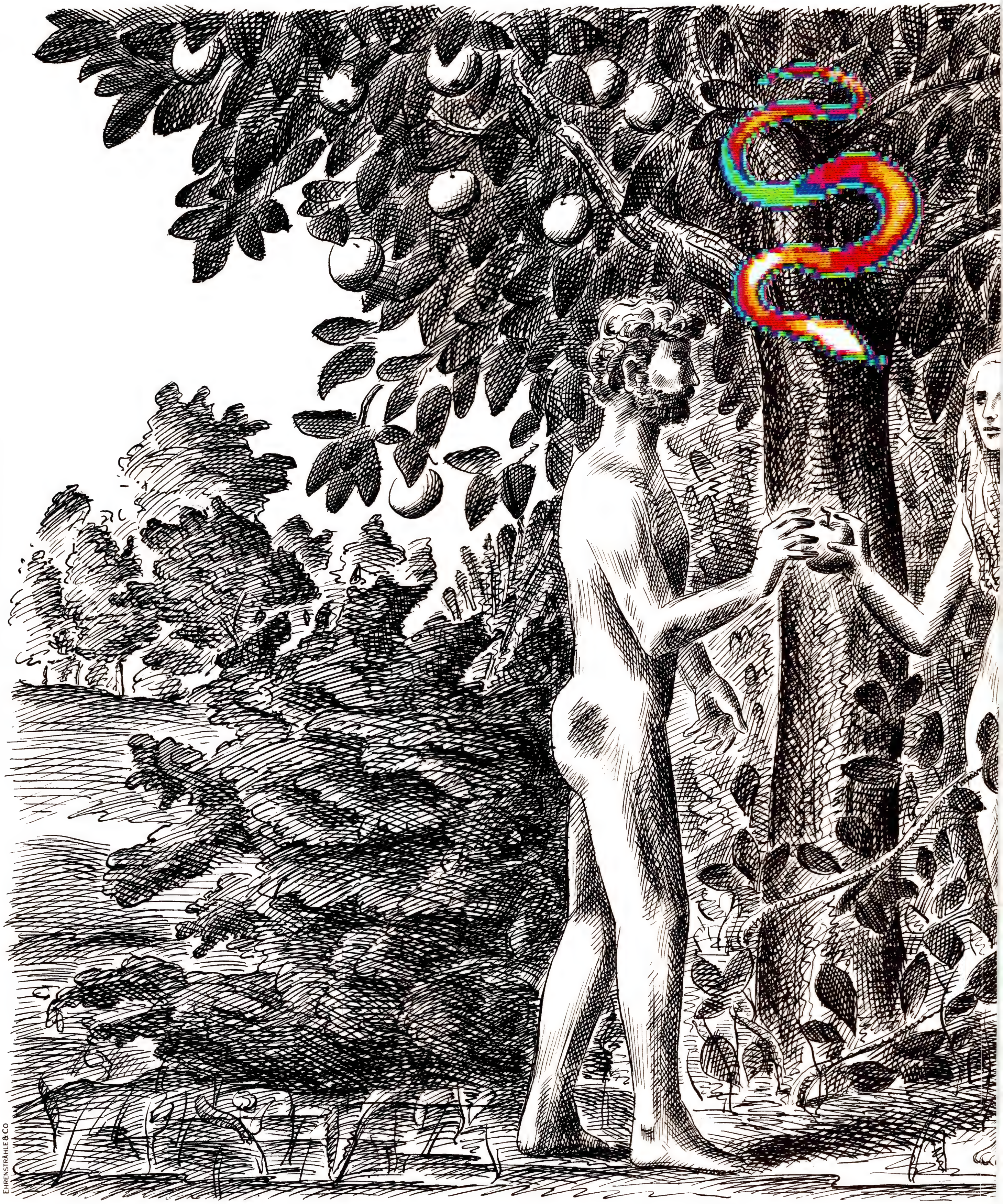
Not sexy, but still a star

Although prospects for steep growth focus a spotlight on digital gallium arsenide circuits, sales of already established analog parts are humming along, too. These discrete components, whose lower densities make them simpler to manufacture, represent about $60 million worth of the current $75 million total GaAs sales. Moreover, such product lines as microwave transistors—for switching high-frequency signals in microwave and fiber-optic systems—enjoy annual growth of more than 30%.

The good business in analog products also can help spur faster development of the digital side, industry officials say. For prices of all GaAs components to drop to levels competitive with silicon, large production volumes must be reached first. To do that, only a consumer-type product that uses many analog parts fills the bill. Industry officials are saying that this goal is not unrealistic, because several promising candidates are in the wings. Topping the list are direct-broadcast-satellite dishes—whose transmitters/receivers use gallium arsenide front-ends—and faster switching digital telephone equipment.

Several firms already are blazing the trail, among them Equatorial Communications Co., which supplies private data networks. The firm recently shipped its 20,000th micro earth station. The design uses three GaAs FETs in low-noise amplifiers. Avantek Inc. provides these amplifiers under an agreement with Equatorial that will be extended to other equipment. A pioneer in GaAs, Avantek has sold FETs since 1974 and monolithic versions for nearly three years. The firm also has a foundry service, produces interfaces linking microwave circuits and digital parts for defense customers, and plans to make digital components. —**L.W.**

There's more to the picture tha



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about making GaAs investments, so companies such as Vitesse are seeking corporate backing. Raymond Dingle, founder and president of startup Pivot III-V Corp., says that the high capital requirements of GaAs scared off venture capitalists, so Pivot's new plant near Somerville, N.J., is being built with money from an unnamed corporate backer.

Dingle, formerly supervisor of exploratory high-speed III-V components at AT&T Bell Laboratories, says Pivot will employ the selectively doped heterostructure high-electron-mobility transistor in all its products. Prototyping will begin in mid-1986 and production a year later. Initial customers will be military.

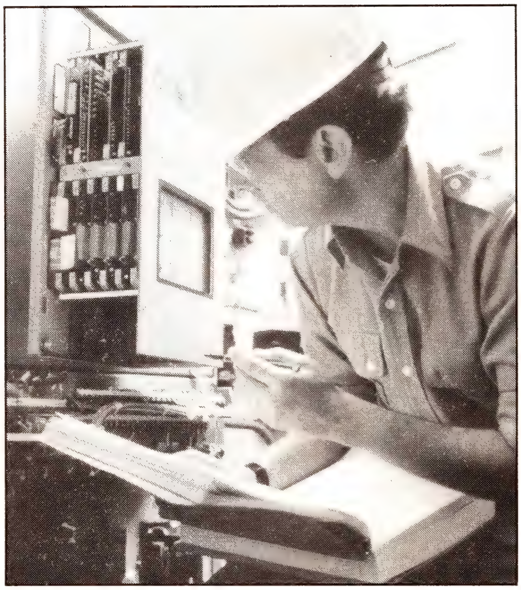
Range of opinion. There is a curious lack of agreement on just what the market for GaAs will be. Ford Microelectronics and researchers at Strategic Inc., an industry consultant, project a demand of 5% to 7% of all semiconductors by 1990, or about $7 billion. But most company marketing officials scoff at such astronomic numbers. Livingston, of Gigabit Logic, puts the figure nearer to $2.5 billion, for both digital and analog. Market research firm In-Stat Inc. sets the projection even lower—$833 million by 1988.

Livingston, in fact, thinks a better tip-off of when GaAs really arrives—which he thinks is still several years away—will be "the entry of big semiconductor companies, which is inevitable." All the top chip manufacturers are known to have projects in GaAs under way internally, according to Eslinger of Morgan Semiconductor. And those showing most interest also have large system operations that use GaAs chips.

Texas Instruments Inc., for example, keeps its GaAs front-ends under its Equipment Group in Dallas, but lets military chip officials monitor merchant market potential. They believe volume business is not yet near, but the firm could start offering products in the military line.

What the business needs most, in addition to cheaper material, is a glamorous product that dramatizes the five- to eightfold speed edge over silicon. One candidate could be the next-generation supercomputer, the Cray-3, which is being designed by Cray Research Inc. with some GaAs components. ☐

DIGITAL DRIVE SAVES STEEL MILL



Keeping count. Digital control of the mill's power supply permits an operator to fine-tune the milling operation and keep a real-time check of system parameters.

Dunkirk, N.Y.

An all-digital drive system for a rod-and-bar steel mill has been put into successful operation by AL Tech Inc. and is saving the firm from bankruptcy. AL Tech, the second-largest U.S. producer of specialty steel, has annual sales totaling more than $175 million.

Its main products—bar, wire, and tubular steel—go into items as diverse as washing machines and jet engines. But cheap foreign competition, until recently not a factor in the specialty-steel market, was forcing AL Tech to choose between death and automation. "We weren't about to bank our furnaces and prepare to receive last rites," says James Mintun, AL Tech's president.

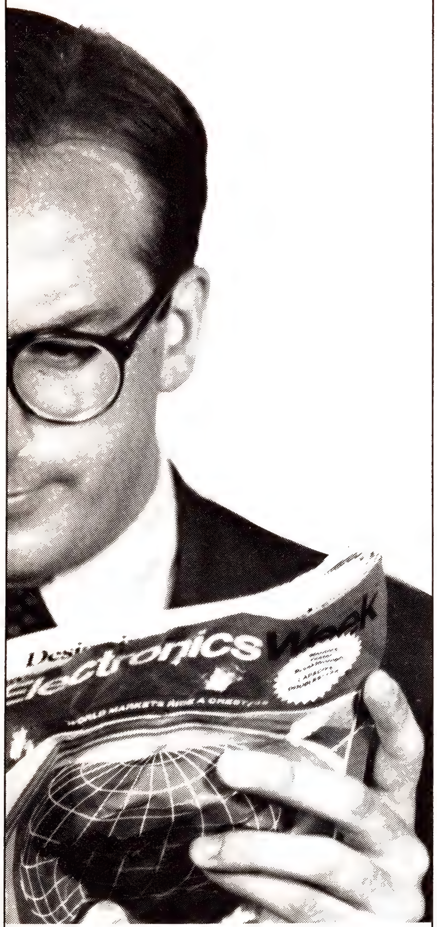
The steel maker had to reduce the amount of ingot it was throwing away as scrap. The electromechanical controls and analog regulators it was using had trouble keeping the speeds of the forging processes matched over the length of the bar. Too often, the bar either got stretched tight or was permitted to droop, resulting in unacceptable deviations from the design specifications.

Fast reaction. The solution was a $1.3 million digital drive system that automatically regulates the rollers' speeds to ensure the proper dimensions for steel products. Designed and supplied by General Electric Co.'s Drive Systems Operations in Salem, Va., it consists of six Siltron silicon-controlled-rectifier drive controls, four distributed microprocessors, and an integrated pulpit (control booth) that was prewired and tested in AL Tech's factory here.

It provides for automatic setup of the hot steel and cascade speed control, as well as product tracking throughout the production process. "The GE system reacts 10 times faster than its [analog] predecessor to correct deviations while the steel is forming," says Tom Lahey, AL Tech's maintenance superintendent.

The Siltron power supply is completely new, a GE representative says. It uses a proprietary digital thyristor to transform the incoming three-phase current to the proper voltage levels for the support circuitry—powering the signal electronics, firing circuits, and excitation modules. Cell-state sensors in each module measure the voltage and provide feedback to the thyristor's microprocessor. The operator at a work cell sees all this information in English on a cathode-ray tube and can react to it easily.

The application of digital electronics to a thyristor is significant in industrial production because it eliminates the drift inherent in analog regulators and allows engineers to deal in drive-system parameters such as seconds and gains, rather than in circuit parameters such as ohms and impedance. **–David M. Weber**



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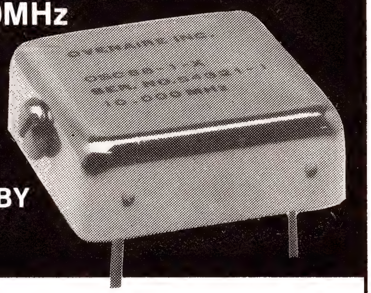

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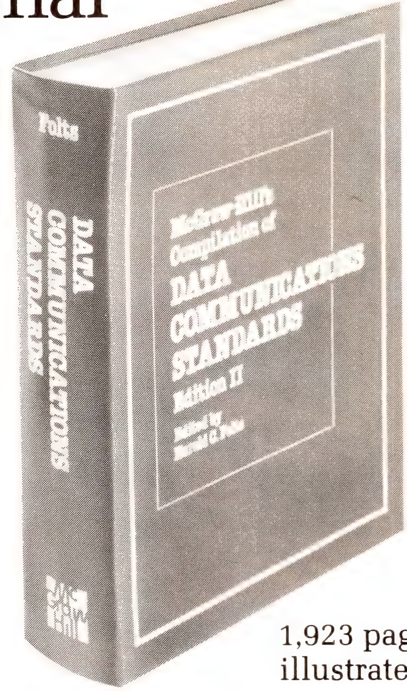
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LIQUID CRYSTALS TWIST FOR CLARITY

Baden, Switzerland

A three-year effort by Brown Boveri & C. AG has culminated in a big-screen liquid-crystal display with a large viewing angle and high contrast. Using a new electro-optical effect discovered by company researchers, the experimental display achieves a bright-to-dark-spot contrast ratio of about 10:1 at normal incidence—that is, when it's right in front of the viewer. From an angle of 45°, the contrast ratio is still a respectable 4:1.

BB&C, essentially an electrical firm with strong activities in power generation and distribution, became involved in LCDs some 15 years ago, having done much pioneering work at its laboratories in this industrial town near Zurich. What prompted the Swiss researchers to turn their attention to LCD contrast problems is the poor image—compared with cathode-ray-tube displays—produced by displays now on the market.

At present, information can be read only with favorable light when the viewing angle is small: the contrast ratio at normal incidence is about 2:1. As the viewer's head moves off to the side, the information all but disappears.

Expensive proposition. One attempt to overcome this problem involves addressing the pixels individually by placing a drive transistor behind each one. However, a large display's 150,000 or so pixels makes the manufacturing costs too high for commercial equipment of this kind.

The BB&C researchers hit upon a simpler, and radically different, approach. The key is a new electro-optical phenomenon—the supertwisted birefringence effect (SBE).

In a conventional twisted-nematic LCD, the orientation of the crystals between the glass plates is off by 90°. Under an applied voltage, the contrast changes only slightly because the brightness-versus-voltage curve declines gradually.

In the Swiss scheme, however, the molecular twist angle is about 270°—hence the name "supertwisted." Applying a select voltage that is only about 10% higher than the usual nonselect voltage causes the molecules to change their orientation abruptly and align themselves almost perpendicularly to the glass plates. Likewise, an abrupt change in the brightness-versus-voltage curve produces a high-contrast display even though the voltage is increased only slightly.

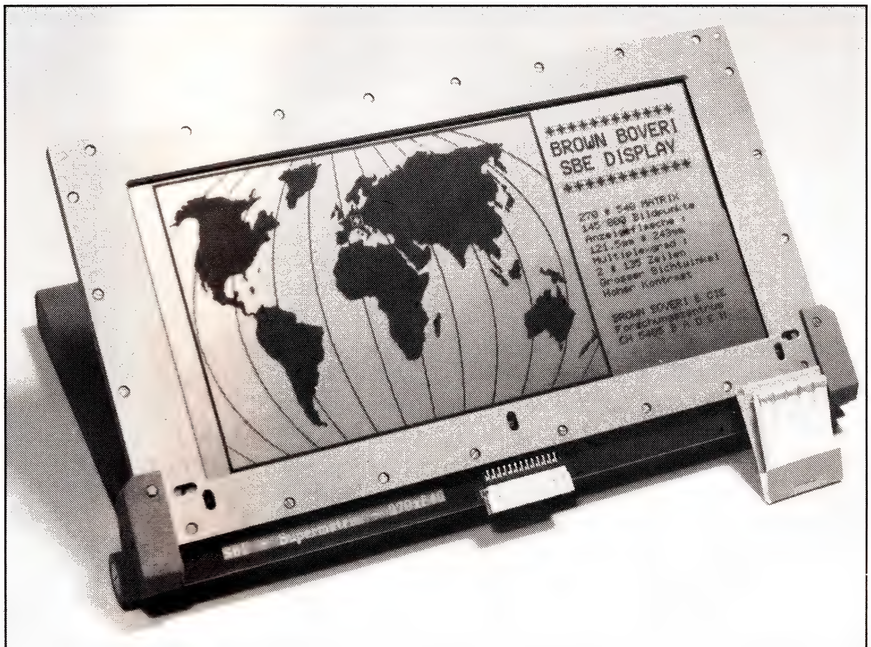
The SBE principle has been implemented in an experimental display with an active viewing area of 4.8 by 9.6 in. In its present configuration, it displays 27 text lines of 89 characters each. The display is about ½ in. thick (which includes the thickness of the integrated-circuit drivers in back of the screen) and has full graphics capability, accommodating 145,800 pixels in a 270-by-540 dot-matrix format. Information switching time is about 300 ms at room temperature.

The Swiss researchers chose to use a double-matrix design, driving each matrix half at a multiplexing rate of 135:1 and bringing the number of connections to a total of 1,350 ([540×2]+270). These are addressed by 30 driver ICs, each of which handles 45 connections. The display's power consumption is comparable to that of a conventional LCD.

The Baden researchers acknowledge that it may take as long as three years of development before the display can go into production. Even then, BB&C will not manufacture the display; it will license other companies.

Limited capabilities. Furthermore, the researchers have no illusions about the display's capabilities. First of all, it is not yet suitable for LCD's biggest potential application—TV [*ElectronicsWeek,* Feb. 18, 1985, p. 61]. For a monochrome set, it lacks the appropriate gray scale; for polychrome, it lacks color. Also, the device is slow: it switches information at only four frames a second, a factor of seven less than it would need for broadcast TV.

But if used to display data in a high-resolution portable format—particularly personal computers—BB&C's invention should be welcomed. And once produced in volume, it should cost the same as conventional LCDs. **–John Gosch**



Bright and clear. Even at an angle, this flat-panel display shows good contrast—appropriate for nontelevised graphics. For text, the resolution is comparable to that of a standard CRT.

SWISS BANK ON LOW VOLTAGE

A nascent semiconductor industry is one positive fallout from the devastation of Helvetia's mechanical watch business

☐ *by Robert T. Gallagher*

Neuchâtel, Switzerland

Faced with the suggestion that the 6-μm metal-gate CMOS integrated-circuit technology that makes up some 80% of his production is about 10 years behind the times, Peter Busch draws X and Y axes that frame a curve shaped very much like a soup plate.

After pointing out that the X axis represents time and the Y axis price, the managing director of Microelectronic-Marin (MEM) explains that the curve represents the typical evolution of prices of ICs based on a given technology. "When a process is new, the prices are high, but they drop very quickly as more and more manufacturers adopt the technology. Then they level off for a number of years," he says.

"But as the same manufacturers move on to new generations of technologies, there is enough remaining demand for the old process to make the prices rise again. And there's money to be made in that part of the cycle."

MEM's the word. MEM is a wholly owned subsidiary of ETA Groupe de Fabriques d'Ebauches SA, which controls the lion's share of the companies that make up the Swiss watch industry. Located in Marin, a town on the northeast corner of Lake Neuchâtel, MEM was founded in 1975, just as it was becoming clear that electronic technology was going to relegate the mechanical watch to the realm of the slide rule.

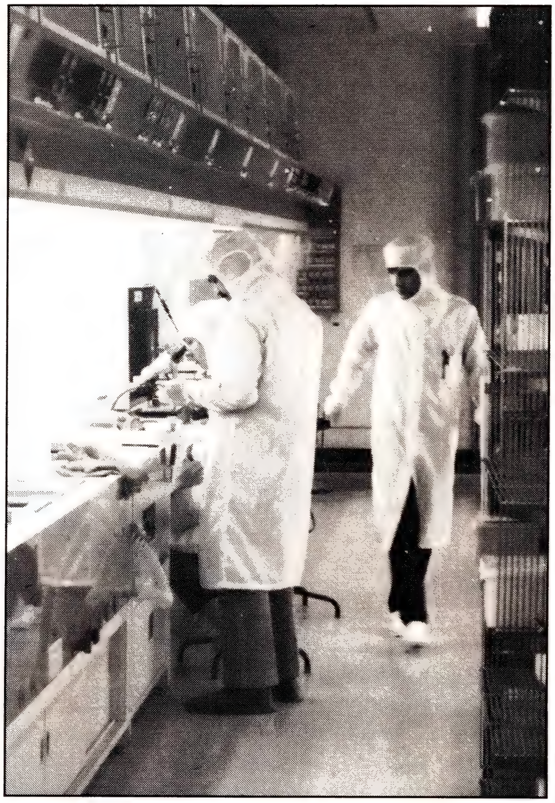
MEM is one of three organizations (the other two are Faselec AG, which is another IC producer, and a government-subsidized research and development establishment) created at about that time to give the Swiss horological industry the electronic expertise to ward off aggressive competition from the Far East.

That industry is now back on its feet, after a painful transition from production of mechanical to electronic timepieces. Now, the three firms are ready to use the capacity and expertise acquired to serve a much broader clientele, both in terms of product offering and geography.

They have little choice. The two IC production companies, for example, have built up a capacity of nearly 20,000 4-in. wafers per month—far more than the Swiss watch industry can consume. And though no one is looking to the Swiss to lead the way in sophisticated IC technology, their work with watches, which impose draconian restrictions on power supply and consumption, has given them more experience, they think, in low-voltage low-current technologies than mainstream semiconductor houses are likely to have.

This is not to say that the Swiss want to apologize for the level of technology they are using. Busch is quick to point out that as long as a process can meet customers' specifications, its level of sophistication is transparent. His 6-μm metal gate, which he produces under license from Hughes Aircraft Co., can still satisfy a substantial range of customer needs. When it can't, he has Hughes' 3-μm high-density CMOS technology up his sleeve.

Just five years ago, 90% of MEM's output went to the Swiss watch industry. That figure is now down to 40%, with 50% devoted to full-custom circuits and the remain-



der to standard products that require low-voltage expertise, such as timers, liquid-crystal-display drivers, and telephone handset circuits.

Busch is aiming MEM at the custom market. He recently signed a licensing agreement with VLSI Technology Inc. for the U.S. company's state-of-the-art IC design software. That tool could make the critical difference in MEM's strategy to grab a piece of the market, currently limited to semicustom circuits and gate arrays, by offering fast turnaround for custom ICs in small to medium quantities. Giving MEM the freedom to attack that strategy, ETA will transform its IC division into an independent company during the coming weeks.

Stays loyal. Despite his diversification plans, Busch has no intention of letting watch circuits become too small a part of his business, an attitude shared by compatriot Heinz Rüegg, president of Faselec in Zurich. Both men say that serving the watch industry adds stability to their activities because the market for timepieces follows cycles far gentler than the roller-coaster rides that characterize the mainstream semiconductor business.

Faselec's situation in the late 1970s (mainly as a supplier to the timepiece industry) may have been very similar to that of MEM's, but its plans for diversification are significantly different. With 75% of its stock held by NV Philips, Faselec has responded to the changing market as a member of that Dutch multinational group.

An integrated circuit to watch

The development of a microprocessor for horological applications at the Centre Suisse d'Electronique et de Microtechnique takes the components usually used in watchmaking to a new level. Until now, the industry had used only hard-wired logic ICs. With a microprocessor now available, it will be able to reap all the advantages of programmability. CSEM thinks its circuit may also find applications outside the timepiece industry.

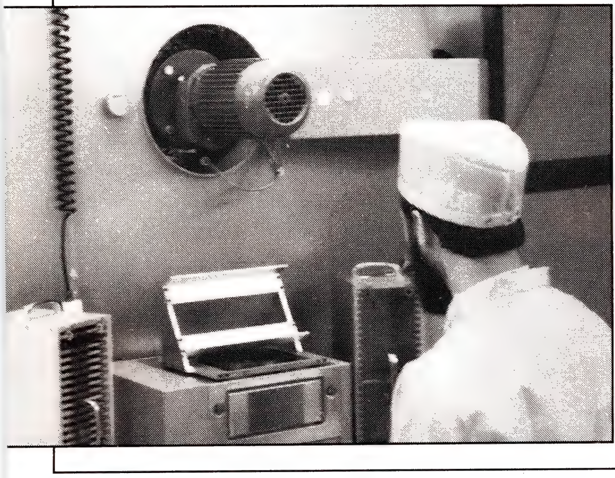
The most stringent requirement for any circuit meant to drive a watch is that it work off a small battery power supply with concurrently reduced consumption. Produced in low-voltage 6-μm technology, CSEM's processor requires only a 1.55-V supply and consumes a miserly 500 nA.

It features both on-chip motor control and a liquid-crystal-display driver so that it can be used with either an analog or a digital watch. To facilitate its use as a consumer product, data can be entered optically through a set of four photodiodes. Thus any jeweler with the necessary apparatus can adjust and reprogram a watch based on the circuit as a regular part of after-sale service.

The processor's instruction set consists of only 12 instructions, each 16 bits long; adding a control bit makes it a 17-bit microprocessor. Any instruction can be executed in one clock cycle; this fact and the small instruction set make the circuit architecturally similar to the reduced instruction set computer (RISC) under development at the University of California, Berkeley.

Christian Piguet, the CSEM engineer who headed the design team, says this philosophy was first chosen to limit power consumption. A side benefit is that, like the RISC computer, it would be an ideal circuit for signal processing or direct execution of high-level languages such as Pascal or Prolog. **–R.T.G.**

Old standby. At MEM (left), 6-μm metal-gate technology is still produced using a wet etching process. For instructional use, CSEM furnishes Swiss universities with IC fabrication techniques such as ion implantation (below) that would usually be beyond their means.



According to Rüegg, just 25% of Faselec's business remains in watch and clock circuits. Slightly more than half is divided evenly between, on one side, telephone handset circuits and ICs based on the Philips I2C two-wire serial data bus—such as the PCD 3343 microcontroller—and on the other side, dedicated peripherals, such as display drivers and assorted memories.

Rüegg's thinking in keeping the remaining 20% of his business in high-volume circuits, such as low-voltage 1-K and 4-K random-access memories, is that Faselec uses its proprietary technology, and "there is simply nothing better to drive a technology than memories."

That self-aligned contact CMOS process, designated SAC-MOS, decreases on-chip clearance problems and simplifies routing so that Faselec can achieve the typical density of a 1.5-μm technology by using 3-μm design rules. That, in turn, saves the small company the cost of investing in a wafer-stepper that the smaller geometry would require.

Quick change. The Centre Suisse d'Electronique et de Microtechnique SA (CSEM) provides research and development support for the native microelectronics industry. Indicative of the diversification that industry is undergoing is that less than a year ago the same unit was known as the Centre Electronique Horologer.

Max Forrer, managing director of CSEM, points out that the center is a nonprofit organization and a private company at the same time. It serves clients ranging from corporate giants to small companies throughout Europe.

For a laboratory of modest means (160 employees and a budget of less than $10 million), it has several impressive achievements. It developed a low-voltage CMOS technology, for limited production and to serve Swiss universities, a process that will soon move to 2-μm design rules. CSEM has developed circuits as complex as a 23,000-transistor 17-bit microprocessor, to be used initially in watches but with a range of other possible applications (see above). ☐

HELMET GIVES GRAPHIC PICTURE

Wright-Patterson AFB, Ohio

Today's conventional military head-up displays (HUDs) will look crudely outdated compared with a new helmet-mounted cockpit display system being developed here by the Air Force Aerospace Medical Research Laboratory (AFAMRL). It will have the system, known as the virtual cockpit, ready for flight tests in two years.

The virtual cockpit features a specially designed helmet equipped with two tiny cathode-ray tubes and associated optics systems. Data from on-board sensors and a satellite-generated terrain data base will be fed into the helmet, giving the pilot a computer-simulated, three-dimensional panoramic scene of the area around his plane. What's more, the pilot will be able to interact with the display—setting up weapons and firing them, for example—by using hand gestures and voice-activated commands.

Joint project. The Army, Air Force, and National Aeronautics and Space Administration have jointly funded the virtual-cockpit effort at about $14 million over the next 2½ years, says program manager Thomas Furness. The Army, which might use the system in its next-generation LHX helicopter, hopes to begin flight tests in two years on a version of the system being developed under a project known as the Virtual Panoramic Display program. NASA would like to use the concept in its next-generation spacesuit, though Furness reports it may have to wait three to four years for a system it can field test.

The helmet prototype developed at AFAMRL employs two circular, 1-in.-diameter CRTs—one for each eye. A complex optical system linked to each CRT bends, magnifies, and collimates the image, projecting it into the pilot's eye. Each eye sees a 60°-vertical-by-80°-horizontal field of view. Half the horizontal view is overlapped—that is, each relay has an identical 40° scene. This provides a total panoramic width of 120° with the middle 40° seen in 3-d.

As the pilot turns his head, the simulated scene changes accordingly, thanks to a helmet-position-sensing system that uses an electromagnetic radiator mounted behind the cockpit seat and a sensor in the helmet. Based on field strengths and phase information, a dedicated processor calculates the helmet's position to within 0.1° of accuracy. Similar sensing packages are also sewn into the pilot's gloves to permit switch activation by pointing.

Weight-reduction plan. The laboratory version of the helmet weighs about 6 lb. Changes for the flight-suitable version aim at cutting the weight to about 3½ lb. One change for the flight model calls for a see-through visor, so that in daylight the pilot can view the real world as well as the simulated scene.

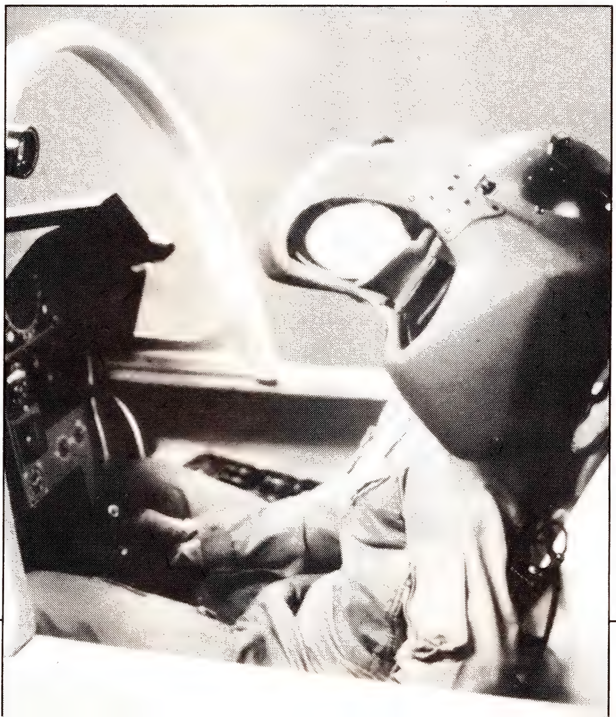
To further reduce the helmet weight, AFAMRL engineers are planning to use smaller CRTs, probably about 0.8 in. in diameter. This will likely be about the smallest size that can accommodate the lab helmet's resolution of 1,000 by 1,000 pixels, says Furness. Thomas Electronics Inc. supplied the 1-in. CRTs and is working on smaller versions. The Air Force has also contracted with Hughes Aircraft Co. and AT&T Bell Laboratories to develop smaller CRTs, Furness notes, and is working with other contractors to provide other parts of the system.

The helmet's weight could be cut further with the development of a holographic system to replace the glass optics used in the lab version. Furness concedes, however, that "there is some risk here, because these kinds of elements are hard to produce."

Natural scene. In addition to the hardware involved, software plays a crucial role in the virtual-cockpit system. A graphics system paints the virtual scene, and other software lets the pilot interact with what he sees. In a HUD system, traditional cockpit instrumentation data is projected in symbolic and coded form onto the aircraft's windshield, and a pilot must form a mental image from the data. In the virtual-cockpit system, software and data aim to build information more naturally into a simulated scene, with the goal of letting the pilot react subliminally to what he sees.

For example, the pilot can check his relative speed by looking at round pillars bordering his flight path in the simulated scene. Hostile and friendly aircraft and ground installations are presented in different colors.

Weapons, also represented graphically, can be fired by pointing and giving voice commands. Through the voice system, the pilot can also modify the virtual scene, so that, for example, he can see a magnified view of only one part of a scene or the view from above his craft. **–Wesley R. Iversen**



World inside a helmet. The AFAMRL helmet provides the pilot with a computer-simulated, 3-d panoramic scene of the world surrounding his plane.

MACHINES AID RELATIONAL PROGRAMS

Los Angeles

Relational-data-base programs get high marks from users with data-processing tasks that involve manipulating huge amounts of information. Available commercially only in the last few years, these programs easily sort through facts from separate places and produce an interrelated report. Moreover, they work from simple query commands and are simple to change and update.

If these data-base software programs have any drawback, it is their slow response during what professionals in electronic data processing call the dreaded sort operation, which drags along through even the fastest mainframe and minicomputer systems. Because some observers estimate that sorting takes about 40% of total computing time and users are notably impatient, improvements could find ready takers.

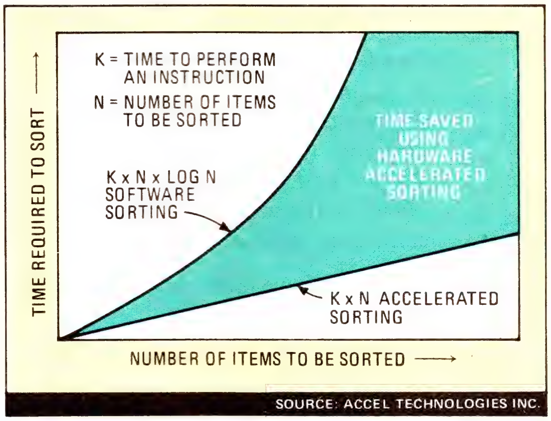
From such problems spring classic hardware niches, and flocking to provide an answer are several West Coast firms. One of the first to come up with a hardware solution was Britton Lee Inc., Los Gatos, Calif., which more than a year ago unveiled its data-base accelerator, bundled into its top-of-the-line IDM 500XL multiuser data-base computer.

System enhancer. Intended for offloading repetitive sorting chores, the Britton Lee machine can handle up to 8 million instructions per second. This streamlines overall system performance as much as tenfold, the firm claims. Next month, Britton Lee will offer the accelerator, with a $37,500 price tag, as an option for its intermediate machine, the 500X. Even for these computers, whose design reflects data-base principles throughout, "it became evident that lowest-common-denominator tasks [such as sorting] need special processors for better data management," says president David L. Britton.

Offering an accelerator as an add-on peripheral, Accel Technologies Inc., San Diego, now has ready its DBA 1000. The firm is now offering its products for minicomputers in Digital Equipment Corp.'s VAX series and Data General Corp.'s MV 8000 line. Accel president Walter A. Foley says the objective is to speed sorting tasks that are offloaded from a host computer's data base. "We all recognize the power of the relational data base, but with it comes its curse—poor performance."

The Accel unit amounts to an advanced machine itself, with an Intel 80186-based front-end processor, bipolar bit-slice architecture for its memory control, and up to five self-sorting memory modules. Balancing these modules implements the firm's patented sorting approach, says Foley. Generally, "the more memory, the faster the processing."

The DBA 1000 sorts a typical inventory file in about 15 seconds; a minicomputer without an accelerator takes about 15 minutes, Accel claims [*ElectronicsWeek*, March 11, 1985, p. 90]. A single unit, with 5 megabytes of sorting memory and 50 megabytes of disk capacity, lists for $37,500.



SOURCE: ACCEL TECHNOLOGIES INC.

Big help. Though relational-data-base programs help users sort through reams of data, the speed of these programs can be enhanced by new hardware accelerators.

For personal computers, Cogent Data Technologies Inc., Bellevue, Wash., offers a single board for IBM Corp.'s Personal Computer XT that gives it the look of a full data-base sorting engine. Sales are starting to build, Cogent says, and a PC AT version will appear in May. The board for the PC/XT sells for $1,750; the AT unit will run $1,995.

Still another firm that is making data-base improvements is Ordain Inc., Los Angeles, which will offer a stand-alone data-base computer that can be plugged into a VAX. Now in prototype, the machine will be available early in 1986. – **Larry Waller**

BUSINESS

DATAPOINT REFOCUSES AFTER BRUISING BATTLE

San Antonio, Texas

Now that the head-butting has ended over control of Datapoint Corp., its greatly relieved president and its new chairman are linking arms to make the troubled computer supplier profitable but smaller. Datapoint is also expected to strike up aggressive new partnerships in the competitive office market and renew the focus on its Attached Resource Computer local-area network.

These are some of the messages from president Edward P. Gistaro, who began meetings last week with Asher B. Edelman. Edelman, a Wall Street investor, replaced Harold E. O'Kelley as chairman after months of lawsuits and threats to sell off pieces of the firm [*ElectronicsWeek*,

Why Does The World's Leading Supplier of Computerized Typesetting Systems Enjoy a Close Working Relationship With HITACHI?

COMPUGRAPHIC'S DAVID J. RAMOS, PROCUREMENT MANAGER OF INTEGRATED CIRCUITS EXPLAINS THE UNIQUE PARTNERSHIP BETWEEN HIS COMPANY AND HITACHI.

Compugraphic Corporation is the world's leading supplier of computerized typesetting systems, and a major purchaser of Hitachi semiconductors.

In a recent interview David Ramos, outlines the reasons for the strong business relationship between Hitachi and Compugraphic, and describes the thinking behind Compugraphic's new ship-to-stock program.

Q. David, could you explain Compugraphic's ship-to-stock program?

A. We are currently developing the details for this program; in the meantime we are recognizing the performance of our higher quality suppliers, such as Hitachi, by significantly reducing our test levels on incoming product. Clearly suppliers like Hitachi will help form the model for our formal ship-to-stock program when it is finally developed.

Q. For this program to work doesn't it require a level of reliability that's unusual, perhaps not even possible, for the semiconductor industry?

A. Apparently not for Hitachi. Our reject rate for Hitachi's 64K DRAMs is 85 parts per million. For the newer 256K DRAM we reject about 1100 out of every million parts. In fact we're not sure what caused those few failures. We may have zapped some of them with a static charge by mishandling, so we've returned some of the 256K parts to Hitachi to determine the cause. Whatever the cause, the failure rate is so low that it is, practically speaking, zero.

Q. Are DRAMs the only parts that Hitachi sells to Compugraphic?

A. No, the particular examples I've used are DRAMs, but Hitachi supports us in many areas. We buy low-power Schottky logic, 68000 peripheral chips, static RAMs and nonvolatile memories as well as dynamic RAMs. We are also considering one-time programmable nonvolatile memories (EPROMs without windows). We've had early presentations on Hitachi's advanced CRT chip and are considering it as well.

Q. Do you have other suppliers that offer you similar support?

A. Some key suppliers that work closely with us besides Hitachi are Texas Instrument and Advanced Micro Devices. They give us good support and have reliable products. However, it would be hard to find a supplier with better overall quality than Hitachi. Because of this we have presented our annual quality award to Mr. Ogu, when he was vice president and general manager and to Mr. Ohnishi, the current vice president and general manager.

Q. You said that the Hitachi rejection rate was about 85 parts per million. How does that compare to other vendors?

A. It's far superior. But, some other vendors have demonstrated sufficiently good reliability to eliminate our usual 100% incoming inspection and to participate in the ship-to-stock program. Texas Instrument is participating in digital logic circuits, for example, but not in memories. Although they haven't led the pack in memory devices, Texas Instrument is a strong competitor. They're probably the only domestic source with the ability to even challenge Hitachi in memories. None of the other domestic competitors even come close from a quality and delivery standpoint.

Q. Don't other Japanese suppliers offer the same quality advantage as Hitachi, as well as a superiority over domestic vendors?

A. Most of the Japanese competitors don't come close to Hitachi. A few years ago it was generally believed that all Japanese suppliers demonstrated the highest quality levels and were far superior to any of the domestic suppliers. Such beliefs raised the quality consciousness of domestic suppliers so that they set about improving quality to meet the Japanese competition. However, we didn't find

"None of the other domestic competitors even come close from a quality and delivery standpoint."

"We select sources of supply with managerial expertise, financial resources, and dedication to our needs."

"We go out of our way to work with Hitachi because we consider them an external resource for Compugraphic."

Advertisement

that general statement about the Japanese suppliers to be true anyway. We found that there were both good and bad Japanese suppliers, as well as good and bad domestic suppliers. By far, when we look at the six major semiconductor suppliers in Japan, Hitachi beats them, hands down.

Support has been a problem with other Japanese vendors. For example, we've had difficulties getting bit maps from other Japanese suppliers with local representation in New England. They just can't seem to correct the communication gap between here and Japan. They do a reasonable job concentrating on the major computer accounts in the area, but they don't pay much attention to other customers. Therefore, they have a very insignificant share of the business at Compugraphic.

> *". . . the failure rate is so low that it is, practically speaking, zero."*

Q. What do you look for in a vendor?

A. We select sources of supply with managerial expertise, financial resources, and dedication to our needs – companies that demonstrate quality and on-time delivery. We're looking for a resource, not an adversary. An adversarial relationship is all too common in this business. One of the things we're proud of is having a good relationship with our suppliers.

Q. What do you feel are the advantages of such a close company-to-company relationship?

A. Because we've developed this partnership with our suppliers, Hitachi and others have supported our increasing demand, even though market demand was high and they had difficulty supporting everyone. Because of this partnership, we never double order, no matter how tight the market, and our backlog is very stable. Furthermore, we do a good job of forecasting, so that our suppliers can plan for our requirements.

It's a two way street. We don't take advantage of our suppliers in a buyer's market, and they don't take advantage of us in a seller's market. We want and expect competitive pricing, but typically in our negotiations we evaluate quality, quantity, and delivery as well as pricing. Pricing is really the last piece of the procurement puzzle.

Q. What do you think of procurement practices that try to squeeze the last penny out of the vendor?

> *"It would be hard to find a supplier with better overall quality than Hitachi."*

A. You get what you pay for. If you're going to purchase parts on price alone, you better be prepared to send quite a few back because you're not going to get the quality or the support that you get with a vendor like Hitachi. My job is easier because there are procurement departments in other companies that try to take advantage of their vendors. When parts get scarce, the vendors would rather sell to those companies that treat them fairly.

> *"Hitachi has supported our increasing (product) demands."*

We don't try to kill the vendors on price during early production either because we understand that they have to get back some of their development cost. It's particularly hard to be the second or third supplier out with a new part because prices have already started to decline and there's not much opportunity to recover investment. Compugraphic would negotiate prices that allow such suppliers to come down the learning curve and recover some of their R&D dollars. We want competitive prices, however, we want our suppliers to be profitable so they can develop the new technologies that we need to increase the performance and reduce the cost of our future systems.

> *"We consider them (Hitachi) an external resource."*

Q. Does this partnership with your suppliers give you any advantages other than quality and an assured source of supply?

A. It gives us a technology lead. We work with our suppliers to influence the technology wherever we can. When we have a problem, we put our technical expertise together with the vendors to resolve the problem. We try to work as a partner with all our suppliers, but go out of our way to work with Hitachi because we consider them an external resource for Compugraphic. We get involved with emerging technologies so that we can plan for it in our design cycle and keep a technological lead in our market. From the supplier's viewpoint, it gives them an opportunity to see what our design plans are at an early stage and "win the socket" for their own upcoming device.

Q. What do you hope to accomplish with a ship-to-stock program?

A. When a company demonstrates very high quality levels, it doesn't make sense to waste money and resources on an extensive testing program. Testing of sample lots is much less expensive than a 100% incoming inspection. We want to minimize that investment in testing by understanding the supplier's process flow and being able to trust the vendor to deliver good parts. There is more involved in good parts than simple non-failure, however. Parts must meet specifications consistently before they can be considered for the ship-to-stock program.

> *"Hitachi has made our partnership work because of the professionalism of their employees."*

One thing that we've discovered about Hitachi is that they spec their devices very conservatively. The parts actually perform better than the written specifications on most parameters. For example, a typical 150 ns DRAM will run 130 ns with no problems. They're very conservative in their specifications so that their devices invariably exceed the specifications. That tells us that they have their process down to where it's very stable. They don't have big swings in quality.

> *"(Hitachi) parts . . . perform better than the written specs. . . ."*

Q. Is there anything you would like to add?

A. From purchasing to upper level management, Compugraphic personnel appreciate the contribution that Hitachi makes to our success. Hitachi has made our partnership work because of the professionalism of their employees. They have a lot of unsung heroes who are always there when we need them. Both upper management and the product marketing managers have given Hitachi a very strong presence in the U.S. – and in Compugraphic.

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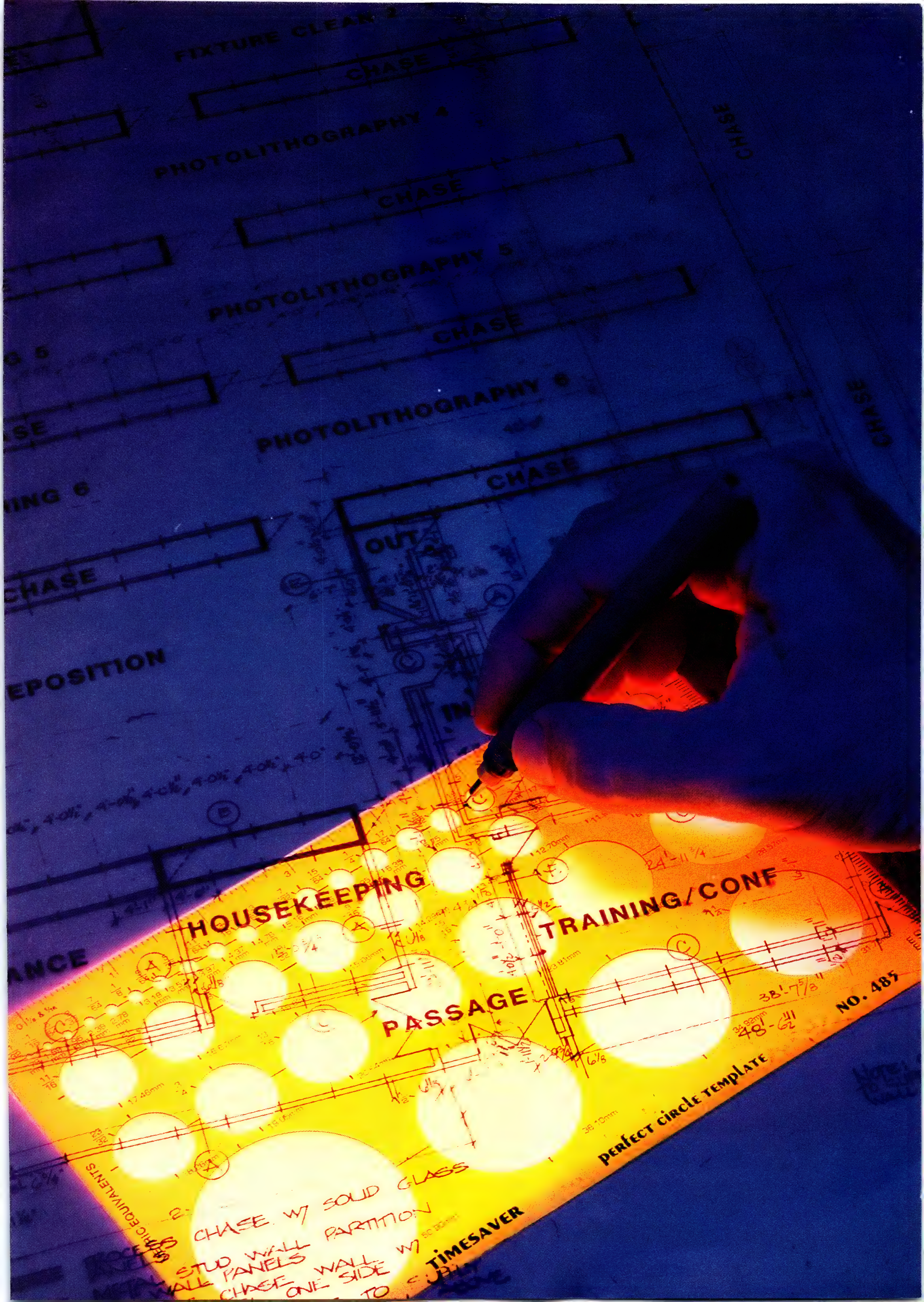
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Tall order. Datapoint president Edward P. Gistaro must "make it clear to employees and customers what our intentions are."

Jan. 7, 1985, p. 35]. Now the task is to assure employees, customers, and investors that the firm will emerge much stronger after selling off various pieces of its business.

"Mr. Edelman's and my job is to make it clear to employees and customers what our intentions are and our commitment to Datapoint," vows Gistaro. "I have no doubt about him and he has no doubt about me."

One thing is certain: Datapoint will sell off pieces of its businesses. Gistaro says customer services and international operations will probably be sold. The company has serious bids—exceeding $200 million—for its customer service business, and it has received offers totaling over $100 million for its core domestic manufacturing operation. Last month, Datapoint sold its Inforex Inc. unit to Recognition Equipment Inc. for $12 million.

Taking care of business. After the sales, Datapoint will emerge as a highly focused firm, Gistaro says. However, industry analysts question whether Datapoint can survive without such operations as customer service and international marketing. "Clearly we will have an ongoing development effort. It will be very much aimed at supporting existing customers and the products they expected from us in the first place," Gistaro promises, referring to the ARC network and the Resource Management System operating system, which he calls "the lifeblood of the company."

The executive also promises more partnerships in the future, noting that "Even IBM makes alliances these days." – **J. Robert Lineback**

COMPUTERS

COLUMBIA UNVEILS NON-VON PROTOTYPE

New York

As the flurry of university activity to develop fifth-generation machines based on parallel architectures begins to bear hardware, researchers at Columbia University have announced the first prototype of their Non-von (short for non-von-Neumann) supercomputer. Three years in development, Non-von 1 was completed several months ahead of schedule.

The general Non-von architecture, of which the prototype is just one part, will consist of about 100 off-the-shelf 32-bit microprocessors, each controlling the execution of many simple processing elements, explains David Elliot Shaw, director of the Non-von project. "The prototype that we've just built, on the other hand, is a very simple version where we have just one of these larger control processors controlling 63 small processors. It's a complete machine unto itself, but it's really a special case of what we envision as the general architecture."

Up a tree. Shaw refers to the Non-von topology as a binary tree, in which the active memory consists of a large number of very small, interconnected processing elements. "In addition, the large processing elements, which are connected into all the small processors at the top part of the binary tree, are themselves interconnected using a very high-bandwidth link."

Based on simulation results, the computer science professor predicts the performance of a larger-scale version of the Non-von, with between 4,095 and 32,767 processing elements, would improve by a factor of 100 to 1,000 for three different artificial-intelligence tasks. These include computer vision and image understanding, knowledge-base management, and expert systems.

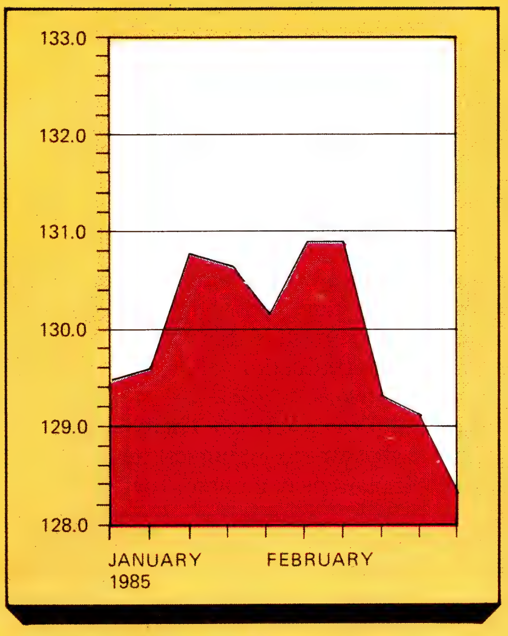
Numbers games. "We have an interest in numerical information processing also," says Shaw. "But the part that we're building right now has not proved to be as successful for numerical applications as it has for symbolic ones."

The prototype's peak and average operating speeds, Shaw says, are not germane because the machine was built to test electrical characteristics and work out the physical design of the machine. However, he does say the next version might be "something on the order of an 8,000-processor machine," operating at 25 billion instructions per second at peak execution speed, assuming full parallelism with 8-bit instructions.

The Non-von project is funded primarily by the Defense Advanced Research Projects Agency and through the Columbia-based New York State Center for Advanced Technology in Computer and Information Systems. IBM, Tektronix, and Digital Equipment all provided faculty grants, equipment, and equipment discounts. Shaw remains hopeful that there will be sufficient funding to build a larger prototype. –**George Leopold**

Parallel prototype. David Elliot Shaw directed the Columbia University team that built the prototype of the Non-von parallel processor.

ElectronicsWeek Index



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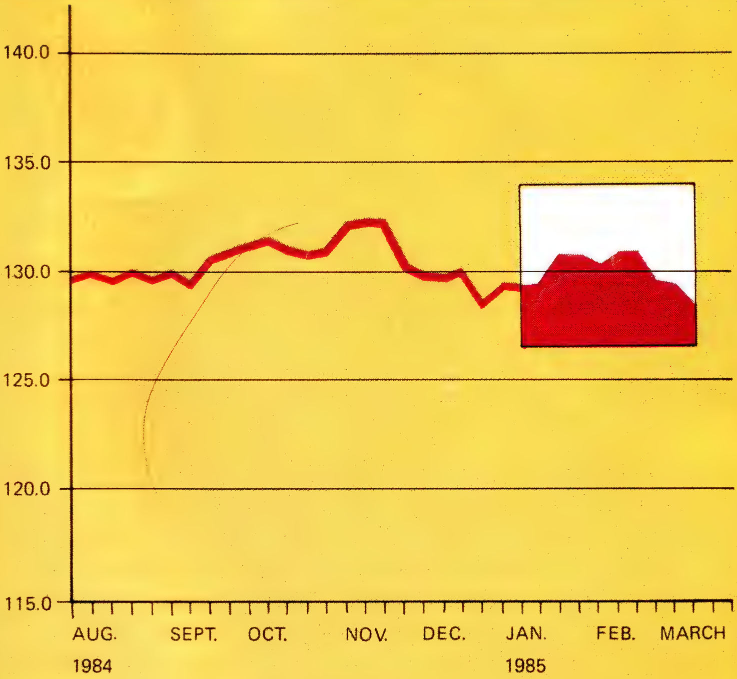


The *ElectronicsWeek* Index, a seasonally adjusted measure of the U.S. electronics industry's health, is a weighted average of various indicators. Different indicators will appear from week to week.

U.S. ELECTRONICS PRODUCTION INDEX

	January 1985	December 1984	January 1984
Office and data-processing equipment	356.6	349.5	300.8
Communications equipment	228.4	225.5	186.6
Radio and TV equipment	87.6	112.9	109.2
Electronic and electrical instruments	179.2	180.3	164.6
Components	458.1	451.4	401.0

U.S. ELECTRONICS COMPONENTS PRODUCER PRICE INDEX (1967 = 100)

	February 1985	January 1985	February 1984
Digital bipolar integrated circuits	60.1	60.3	63.6
Digital MOS ICs	42.7	42.1	42.4
Linear ICs	60.0	59.9	63.6
Capacitors	192.2	192.5	192.0
Resistors	187.7	186.4	179.4
Relays	312.4	319.3	303.0
Connectors	230.6	232.4	226.2

TANDY ISN'T QUAKING THOUGH PC MARKET'S SHAKING

Fort Worth, Texas

The thought of a shakeout in the unstable personal computer business doesn't rattle Tandy Corp. The electronics retailer, which also became a computer maker in the late 1970s, is a veteran of sudden market explosions and the inevitable implosions that flatten most contenders.

"We have been fighting this kind of battle for a long time in a lot of fields," assures Ed Juge, the company's director of market planning, who has helped to guide Tandy's broad line of business and consumer computer systems.

Today, the company that got its start retailing leather-craft kits now owns more than 6,000 Radio Shack stores and computer centers worldwide, plus nearly 3,100 additional dealerships in small towns. It employs 28,000 full-time workers, shows profits of $282 million on $2.7 billion sales, operates assembly plants in North America and Asia, and has one of the largest lines of microprocessor-based computers—eight models, not counting its line of pocket-size computers.

Some consider consumer markets good training grounds for survival in future electronics-systems businesses. For example, when the boom in citizens' band radios hit the industry in the 1970s, Tandy entered early with a full line of CB products sold through its network of Radio Shack outlets.

"Our market share went down as the CB boom went up, because people started giving them away while we attempted to maintain profitability," recalls Juge. "We survived while most others did not, and today we have an extremely large share, probably 35% to 40% of the total [market for CB radios]. Personal computer market trends are just kind of a replay of what we have been through before."

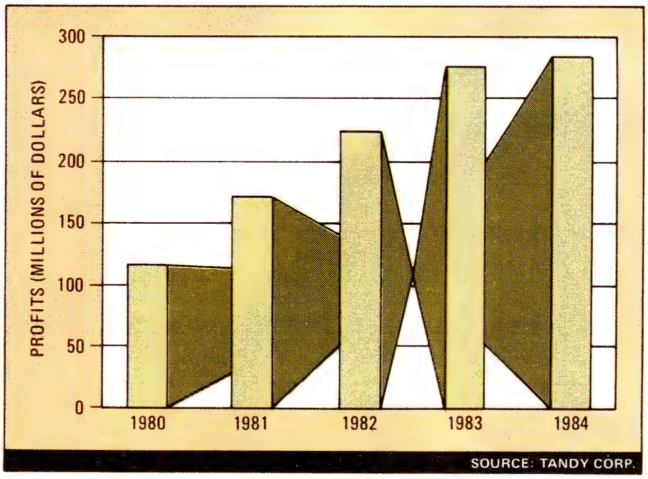
Play it again. It may be a familiar replay in the consumer retailing marketplace, but Tandy is also looking for ways to prop up its chances in the business-systems arena. Last year, Tandy reorganized its sales efforts to companies under a new Business Products Division.

This revamping incorporates several elements:

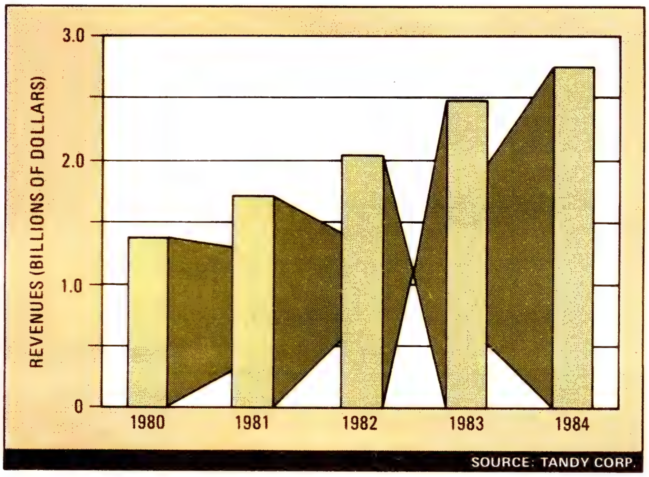
- Less use of the Radio Shack name.
- Entry into cellular telephone markets this spring.
- Fast-turnaround service centers that can repair and return systems to users in a day.
- Introduction of a new local-area network.
- Promotion of Tandy's lead over all other manufacturers in shipments of computers that run AT&T Bell Laboratories' Unix operating system (Tandy's 68000-based 16-bit Model 16 and the new Model 6000 are available with Xenix, the implementation of Unix that was developed by Microsoft Corp.).

Current estimates from Yates Ventures, a Unix market watcher, say Tandy has some 35,000 Unix systems in the field, compared with 18,000 from Altos Computer Systems, the second-ranking Unix supplier. "Primarily, that's because Tandy is the low-end Unix supplier," notes Kirsten R. Sanders, a senior market research analyst at Yates.

"If you want an inexpensive Unix system for hobbyists, a small engineering company, or even a multiuser system for a small office, Tandy has the lowest price and most available system today," she points out. Tandy's Model 6000, with a 15-megabyte hard disk and 512-K bytes of main mem-

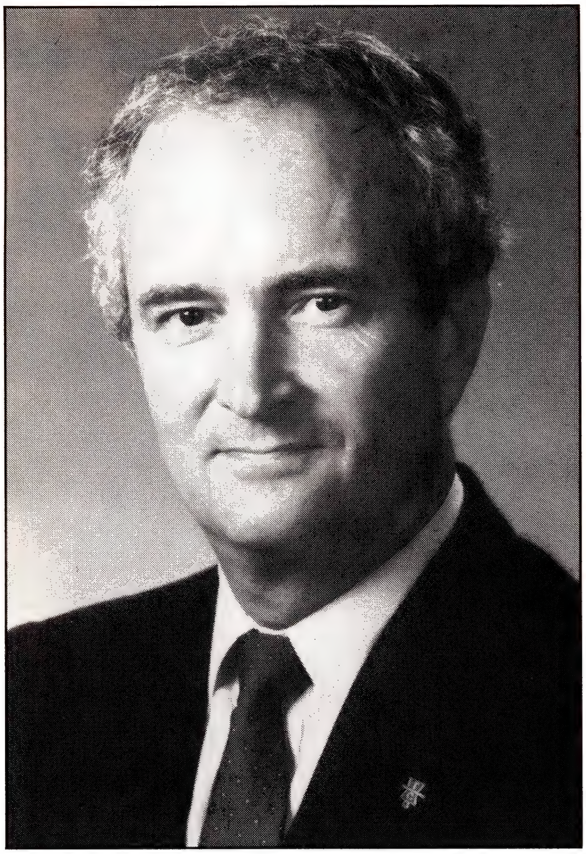


SOURCE: TANDY CORP.



SOURCE: TANDY CORP.

Slow going. Tandy Corp.'s net income (top) stagnated in 1984, growing just 1% to $282 million from the previous year's $279 million. This occurred in spite of an 11% increase in revenues (bottom) last year to $2.7 billion from $2.5 billion. The company hopes that a reorganization will help it successfully penetrate the business-systems market.



Old hat. "We have been fighting this kind of battle for a long time in a lot of fields," says Ed Juge, the market planning director who helped guide Tandy's line of computer systems—including the new Model 6000, which has a 15-megabyte hard disk and 512-K bytes of main memory.

ory, made its market debut in February at a price of $5,499.

In addition to Unix, Tandy has a line of systems, based on the Intel Corp. 8088 and 80186 microprocessors, that runs Microsoft's MS-DOS or PC DOS for compatibility with IBM Corp. Personal Computers. Last fall, Tandy introduced its Model 1000, which is fully compatible with application packages running on the IBM PC. Priced at $1,199, the unit also contains extra standard features, such as color-monitor connection, parallel interface, graphics and sound enhancements, and a port for a joystick and light pen.

The unit has outsold any previously introduced Tandy computer to date and "continues setting records since day one," adds Juge. For more demanding office use, the nine-month-old Model 2000 can execute MS-DOS programs three times more quickly than the IBM PC.

Communications network. In addition, Tandy plans to boost its presence in office markets for LANs by introducing this month a product called Vianet. The network will run on its MS-DOS systems. A similar version of the new network, developed by Vianetix Inc., of Boulder, Colo., will be offered by Wang Laboratories Inc.

Vianet, which does not require a dedicated network server, will be made available on Tandy's Xenix 68000-based Model 6000 system during the second half of this year. Currently, Tandy has been enjoying only minor sales success with the Attached Resource Computer (ARC) licensed from Datapoint Corp., of San Antonio, Texas. Tandy's only pathway into ARC is through its 8-bit Model 12, running the Tandy proprietary Trisdos operating system.

But Tandy's ability to succeed in business markets is less certain than its nearly unquestioned ability to weather the storms ravaging home computer markets, says Bill Meserve, senior management consultant who watches information processing and consumer electronics at Arthur D. Little Inc. Meserve thinks Tandy's merchandising skills will not be of much help against IBM.

"I think the euphoric optimism has been replaced a bit at Tandy by realistic optimism, even by the likes of [Tandy] chairman John Roach," Meserve points out. "They have done modestly well, but these 'fortunate' successes may have temporarily glittered the efforts and temporarily blinded Tandy." Meserve expects sales at Radio Shack stores to gradually shift and put more emphasis on the firm's proven success—consumer electronics.

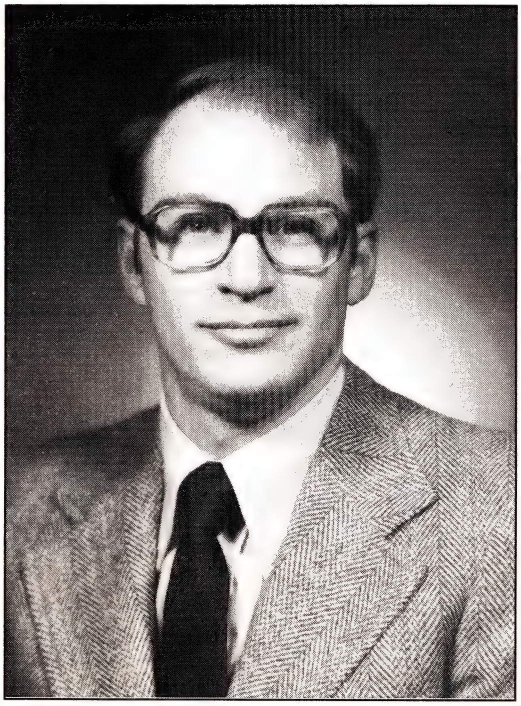
Computer-related products account for a third of all Tandy sales, and Juge says Tandy is well positioned—with its own manufacturing plants and retail stores—to take on IBM, Apple, and any other contender for business sales.

"We are extremely vertically integrated with plants that take raw fiberglass and make our own circuit boards. We make our own power supplies and cable harnesses. Nearly everything except for our own silicon—but that's a minor expense, especially these days," he says. "If we can compete with the Japanese companies in consumer areas, I surely don't think we have any problem taking on anyone in the computer industry."

Back to its roots. The company, which entered electronic sales with the 1963 purchase of the regional chain of Radio Shack stores in Boston, is certainly not backing away from its consumer roots. Home satellite receiving dishes and stereo TV are two items in Radio Shack's 1986 catalog, which will be out late this summer.

In addition, a joint development venture with Mobira of Helsinki, Finland, will result in Tandy's introduction of cellular-radio phone sets this spring. Tandy plans to drive the price low enough to make it a volume consumer market, according to Roach. **– J. Robert Lineback**

MAYO'S GILBERT SAYS GaAs CIRCUITS ARE ON VERGE OF MEDIUM-SCALE USE



Digital GaAs due. Head of a group involved in GaAs work at the Mayo Foundation, Barry K. Gilbert predicts medium-scale commercial use by next year.

Rochester, Minn.

Based on design projects under way at a number of electronic systems houses, industry watchers can expect to see the first digital gallium arsenide chips showing up at medium-scale-integration levels in commercial systems by next year. But the architectures employed on those products are likely to be radically different from those found on their silicon counterparts.

That view comes from Barry K. Gilbert, a staff scientist at the Mayo Foundation here, who is in a position to know. As head of the Mayo Foundation's Special Purpose Processor Development Group since it was formed in 1971, Gilbert and his group have been involved with GaAs chip and system-level considerations since 1980. An electrical engineer who earned his bachelor's degree from Purdue University in 1965 and joined Mayo that same year, the 40-year-old Gilbert also holds a PhD in biophysics from the University of Minnesota.

Gilbert has a window on the latest in the technology thanks to his role in a program, supported by the Defense Advanced Research Projects Agency, aimed at production of dense GaAs digital chips. As a contractor funded at about $4 million over the next three years, the Mayo group is working with a Rockwell-Honeywell team on the effort, and its responsibilities include computer-aided-design systems and packaging development.

Under the Darpa contract, "We're also responsible for worrying about system-level considerations," Gilbert says. "In other words, now that we have the capacity to design things on gallium arsenide chips, the question becomes what should we put on them." The Mayo group has a significant effort under way for determining the best kinds of chip architectures for GaAs digital integrated circuits, and is already working on the first customization for a 5,500-gate GaAs array to be fabricated under the project.

Because GaAs is in its infancy as a digital-chip technology, the parts' density levels are naturally much lower than those achievable with mature silicon technology. But, Gilbert says, "I'm not sure that GaAs needs to compete on a gate-count-for-gate-count basis with silicon." The reason is that "the strong suit of GaAs is very fast gates."

Repeat signals. The Mayo official predicts that designers of GaAs chips "will want to exploit structures which reuse the available gates on a chip very many times." Silicon-chip designers typically go for higher speed and performance by increasing chip density and adding parallel structures.

For lower-density GaAs chips, however, designers must "figure out algorithms that are iterative or recursive, or cell-like in their structure, so that the signals stay on chip and perhaps even recirculate through the logic as many times as possible before they're taken off the chip."

The Mayo Foundation's interest in GaAs technology stems from the need for signal processors capable of extremely high clock rates for data-intensive medical applications at the Mayo Clinic and the Mayo Medical School. These include molecular modeling and high-speed number-crunching of data from computerized tomography scans and other medical imaging systems.–**Wesley R. Iversen**

IRELAND'S HANNAH LURES U.S. FIRMS WITH BUSINESS INCENTIVES, NOT BLARNEY

Santa Monica, Calif.

The window looks out on a sunny California beach town, but the slight lilt in David P. Hannah's soft voice makes his nationality unmistakable: Irish to the core. Although now living far from the Emerald Isle, Hannah is engaged in important work for his homeland. As West Coast director of its Industrial Development Authority, he must convince U.S. high-technology firms looking for a European expansion site that Ireland has the most business advantages.

How well his approach works was underscored in January when the IDA bagged its biggest prize to date:

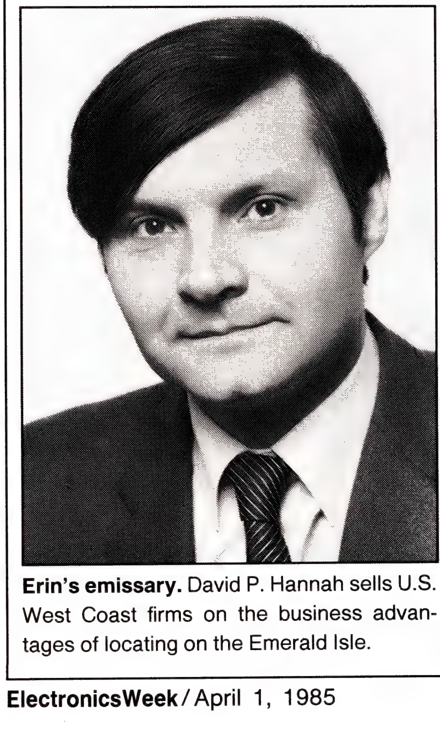
a $186 million semiconductor fabrication plant that Advanced Micro Devices Inc. will build near Dublin beginning by October. It could employ more than 1,000 workers in full operation.

Though the AMD project is a coup, coming against intense competition from European rivals—chiefly Scotland and Wales—it is by no means an isolated event. In 1973, Ireland had only 23 electronics plants; now, some 130 factories contribute about $3 billion of products, or one quarter of Irish exports.

Evidence, not blarney. For the 10 years before Hannah came to his present post, in early 1984, he headed the agency's electronics program from Dublin and played a major role in its growth. Contrary to what some might think, selling Ireland's mystique is not the ticket. Instead, the challenge is to prove to prospects the tangible advantages of locating in Ireland—and to keep making the pitch. Picking off the AMD expansion, for example, meant visits to the Sunnyvale, Calif., firm's headquarters over an eight-year period.

During his tenure, the 41-year-old Hannah has played a central role in bringing General Electric, Digital Equipment, Apple Computer, and NEC to Ireland. As to his achievements, Hannah rates involvement in establishing three research institutes in Ireland as the most satisfying.

A plethora of university courses in electrical engineering and computer sciences is taken for granted in the U.S. But until the early 1980s, when the institutes were founded, few such programs were available in Ireland. "This is the infrastructure for industry to sustain itself on, to supply the specialists companies need," Hannah asserts. He says he acted as a conduit, "explaining the needs of companies, so the centers can respond to the marketplace." The institutes do work in semiconductors, applications, and software.



Erin's emissary. David P. Hannah sells U.S. West Coast firms on the business advantages of locating on the Emerald Isle.

Tax advantages. The usual package that many countries offer to lure new plants includes providing sometimes up to 50% of the building cost, but Hannah says Ireland goes further with an incentive that seems to work. "We levy virtually no tax on profits until the year 2000." Competing countries have high corporate rates, according to Hannah.

The location of the IDA's West Coast office in the Los Angeles area, instead of Silicon Valley some 300 miles north, takes advantage of the rapidly growing nearby Orange County-San Diego technology complex nearby. But Hannah expects to remain here no more than five years; IDA's policy is to rotate everyone home periodically to keep them up on the Irish technology scene, which is changing too rapidly to follow closely from afar. **–Larry Waller**

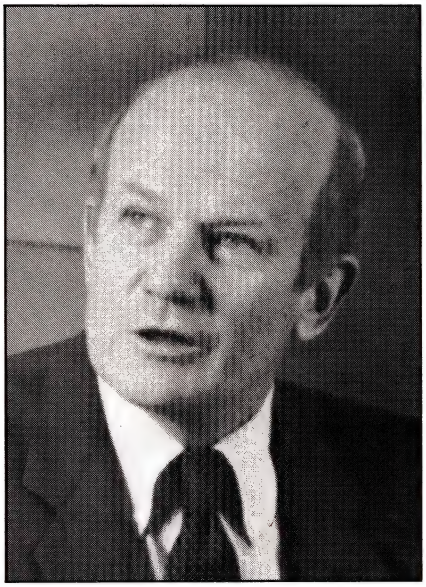
IT'S SELDOM BUSINESS AS USUAL FOR MCFADDEN OF ITT AME

Brussels

Any businessman who wants a neatly defined product line to sell in a homogeneous market need not apply for Bernard J. McFadden's job. As president and chief executive officer of ITT Africa and Middle East, the multinational's sales and marketing organization for that region, he is responsible for planning and executing ITT's business growth in 66 countries whose economic situations run the gamut from the misery of Ethiopia to the rich and developed Republic of South Africa.

Managing this very study in heterogeneity is no simple task. The 51-year-old executive grins and explains factors he must take into account in going about business: "The least you can say is that it isn't a perfect science. For one thing, you always have to be aware of the political facts of life in these countries, and business is often done differently from the way that we're used to. It's not unusual, for example, to find situations where contracts are awarded before the tenders are even made."

Pent-up demand. "The way you have to go about it is to take a rifle approach, by picking a specific country and analyzing its profile and resources, like the industrial base," he reasons. "Basically, you've got to match up prior experience with a friendly government in an effort to find a pent-up demand to satisfy."



Third-world marketeer. Bernard J. McFadden plans ITT's business growth in Africa and the Middle East.

McFadden joined ITT in 1963 and was appointed president of ITT AME in 1982. He considers penetration of that part of the world with ITT's System 12 digital telephone exchange one of his biggest challenges. His organization has already sold the digital switch to Turkey, where it will be locally produced. Other target countries are Egypt, which has plans to upgrade its network to full digital status, Algeria, and Nigeria, where the company already holds nearly 80% of the market with its analog switch, the predecessor of System 12. **–Robert T. Gallagher**

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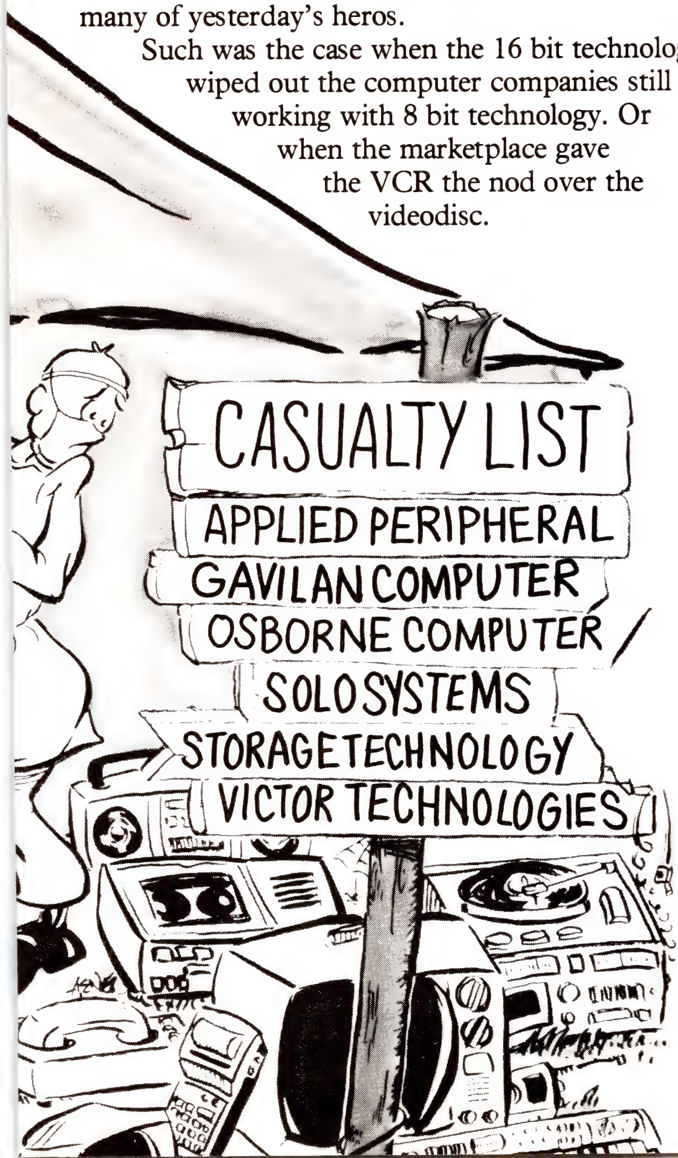

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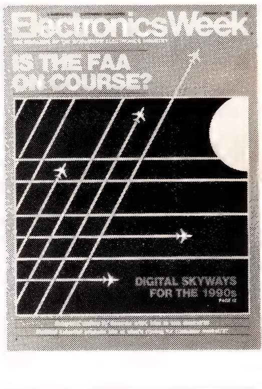

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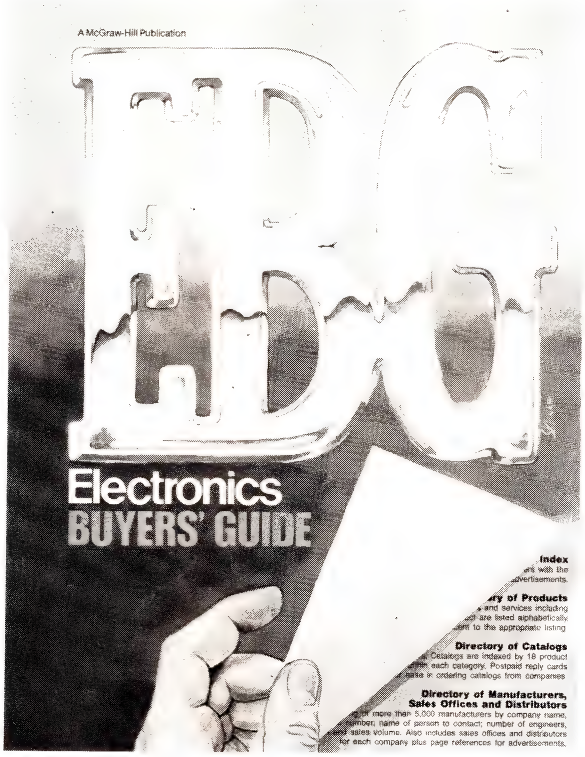
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SPECIAL REPORTS

WAFER-SCALE FACES PESSIMISM

But some companies forge ahead despite yield, reliability, and cost problems—and some second thoughts

☐ *by Bernard Conrad Cole*

Only one word can adequately describe the attitude of engineers, designers, and company executives toward wafer-scale integration—ambivalence.

Born of numerous efforts by semiconductor and computer-system companies to build not only workable but cost-effective wafer-scale integrated circuits, the conflicting feelings are most evident at conferences and sessions devoted to the subject. At these meetings, the questions and comments from the floor range from the burnt-finger pessimism of a number of leading semiconductor and computer companies with failed efforts at wafer-scale integration to cautious optimism from academic researchers who are experiencing modest success.

Since 1979, there have been at least a dozen attempts by commercial semiconductor and computer firms to develop workable wafer-scale programs. Almost all have been discontinued, though not for technical reasons. Rather, it was determined that the techniques were neither cost effective nor cost competitive with existing approaches to very large-scale integration. In the U.S., most of the work is confined to a small number of major university laboratories and private research centers.

The few established electronics and computer firms still in the running can be counted on the fingers of one hand: General Electric, GTE, Honeywell, Texas Instruments, and TRW. IBM Corp. is also reported to be working on wafer scale, but the company will provide no details.

Of the four startup firms established to bring wafer-scale products to market, one—Trilogy Systems Corp.—publicly announced failure and a second—Waferscale Integration Inc.—has not as yet reported any products. The third firm—Mosaic Systems Inc.—is the furthest along in producing a commercial wafer-scale product. Before midyear, the Troy, Mich., firm should deliver first samples of its wafers, containing about 50 logic and memory chips, to its customer and investor, Evans & Sutherland Computer Corp. The fourth firm, Inova Microelectronics Corp., Campbell, Calif., is working with a major Silicon Valley semiconductor manufacturer and hopes to market an 8-Mb wafer-scale CMOS random-access memory.

Adding to a thus-far dismal showing are a number of studies indicating that for most applications, wafer-scale integration is not practical. For example, a study by C.A. Neugebauer, manager of semiconductor packaging at General Electric Co.'s Corporate Research and Development Center, indicates that a number of existing advanced hybrid-VLSI packaging approaches can achieve circuit densities, performance, and costs comparable to

TABLE 1: FIGURES OF MERIT FOR WAFER-SCALE VERSUS VLSI PACKAGING (100-MHz CLOCK RATE)

Package	Power versus delay (normalized)	Size or weight (normalized)	Cost (normalized)	Overall figure of merit
Printed-circuit board	1.00	1.00	1.00	1.00
Thick-film multilayer on ceramic	1.08	0.42	1.02	0.46
Ceramic multilayer hybrid	0.34	0.20	0.65	0.044
Thin-film multilayer hybrid on various substrates, populated on one side	0.19	0.14	0.60	0.016
Wafer-scale integration	0.01	0.09	0.46	0.0041
Thin-film multilayer hybrid on various substrates, populated on both sides	0.08	0.07	0.44	0.0025

wafer-scale integration. Wafer-scale loses out in all cases to thin-film hybrids in terms of cost, performance (power multiplied by delay), and size or weight for systems that require at least a 100-MHz clock rate.

In terms of packaging density, thin-film multilayer hybrids on various substrates, when populated on both sides, can pack almost 25% to 30% more components in about the same area as a wafer-scale package. The two technologies are almost equal as far as package delay is concerned; double-sided thin film hybrids rate 10.5 ns, versus 11.8 ns for wafer-scale when both have 450 output buffers per package. In terms of power per chip, both single- and double-sided multilayer hybrid approaches are in the same ballpark as wafer-scale packages. When the product of power times delay—the accepted figure of merit used to compare technologies—is considered, double-sided thin-film hybrids again clearly come out on top, and costs are also approximately equivalent (Table 1).

Cost-effective in combination

Neugebauer's report concludes that wafer-scale integration can be cost-effective only when it is used in combination with a thin-film approach, similar in many respects to the method used by Mosaic Systems. Neugebauer's broad-brush analysis is largely supported by a more detailed study by James M. Daughton, vice president of Honeywell Inc.'s Solid State Laboratory.

TABLE 2: RELATIVE BENEFITS OF VARIOUS WAFER-SCALE INTEGRATION REPROGRAMMING AND REDUNDANCY TECHNIQUES

Technique	Type	Process requirements	High-voltage node-isolation required
Electrical on-chip transistors with poly fuse	Disconnect	Polysilicon	Yes
Laser-programmed poly fuses	Disconnect	Poly	No
EPROM cell	Disconnect	Famos	Yes
Electrical off-chip signal with metal fuses	Disconnect	Double metal	Yes
E-beam-programmed poly fuses	Disconnect	Poly	No
E-beam-programmed aluminum fuses	Disconnect	Poly	No
Laser-formed links	Disconnect	Poly, aluminum copper silicon	No
Electrically programmed poly diodes	Connect	Poly diodes	Yes
Laser-restructured vias: interlevel metal	Connect	Poly, amorphous silicon, quartz	No
Laser-restructured vias: metal to diffusion	Connect	Poly interlayer	No
Laser-connected metal gap	Connect	Silicon dioxide on poly and silicon dioxide	No
Laser links	Connect	Poly, AlCuSi	No
E-beam-connected metal gaps	Connect	Amorphous Si	No
Laser-programmed poly resistors	Connect	Poly resistor	No
Antifuse	Connect	Amorphous Si	No
Electrically programmed oxides	Connect	Thin gates	Yes

The report, which focused on cost tradeoffs, indicated that with today's technology the wafer-scale integration of random logic requires the use of unreasonably small elements. In addition, it is subject to high and unstable defect densities. Wafer-scale memories, on the other hand, can be produced with very reasonable element sizes, Daughton says.

His analysis indicates that with current state-of-the-art technology approaching submicron geometries, an attempt to create a random-logic wafer-scale circuit any larger than 2 in.^{2} is a risky endeavor, even with redundancy. With standard double redundancy and laser-based connection/disconnection to replace faulty elements, the die must be kept quite small—not more than 20 by 30 mils—to achieve a realistic density of five defects per square centimeter. Even with micron or submicron technology, however, the circuits would contain barely enough logic to find a commercial market.

Because memory circuits consist of regular patterns of identical elements, they are an entirely different matter, says Daughton. Memory arrays can be built from identical subarrays using a regular interconnection scheme, which makes it possible to use a global pool of spares as well as a logical-to-physical address-translation scheme to replace faulty subarrays. His results show that with chip-level repair, wafer-scale integration for memory arrays is potentially very attractive, if the relative overhead circuitry can be kept under control and the global overhead wiring can be kept small.

"With an appropriate global wiring and address-translation process, it seems possible to achieve a memory yield of 50%, where about 20% to 25% of the wafer area is usable for good arrays," he says. "Within these constraints, the cost of a wafer-scale memory would then be about twice the wafer-processing cost." Despite the enormous difficulties to be overcome and the many failures encountered so far, companies and researchers around the world find the potential advantages of wafer-scale integration attractive enough to continue their work.

Up to now, most Japanese efforts in wafer-scale integration have focused on memory designs. Since the announcement of the national supercomputer effort, however, considerable unpublicized effort has gone into the development of non-von-Neumann architectures. Most of the memory work has taken place at Nippon Telegraph & Telephone Public Corp.'s Electrical Communication Laboratory. An early effort was a wafer-scale RAM fabricated on a 3-in. wafer using 4- to 5-μm design rules. Organized as 32 K words by 40 bits, the wafer is divided into upper and lower halves with two quadrants and the same structure in each. Each quadrant has 16 fundamental storage units (1 K word by 20 bits, each word with two spare bits) and 7 spare units.

The expected yield on such a wafer is about 90%, provided that the yield on each storage unit is at least 25%. A later version of the same part uses discretionary wiring employing fusible links, in which defective memory cells are effectively removed by applying excess power to blow specially placed links.

In the read-only-memory area, the same lab has developed a 4-Mb ROM designed as a Chinese ideograph character generator. Composed of four 1-Mb-modules and two module-select circuits on a 3-in. wafer, the full-wafer ROM can store 15,040 characters of a 16-by-18 matrix. It has 16 bit-address inputs, 16 data outputs, and 4 timing-control signal lines. Access time is 12 μs and the data-transfer rate is 16 Mb/s, adequate for use in printers and cathode-ray tubes.

The laboratory's most recent effort is a 3.75-Mb full-wafer RAM fabricated using a mix of n-well CMOS in the periphery and resistive-load n-MOS in the memory array [*Electronics,* Jan. 26, 1984, p. 77]. The 4-in. wafer memory can store a 512-by-512-dot-matrix display in 64 colors for graphic displays. The effective capacity is 1.5 Mb, configured as 256-K by 6 bits with 100% redundancy, resulting in 50% yields using 3-μm geometry.

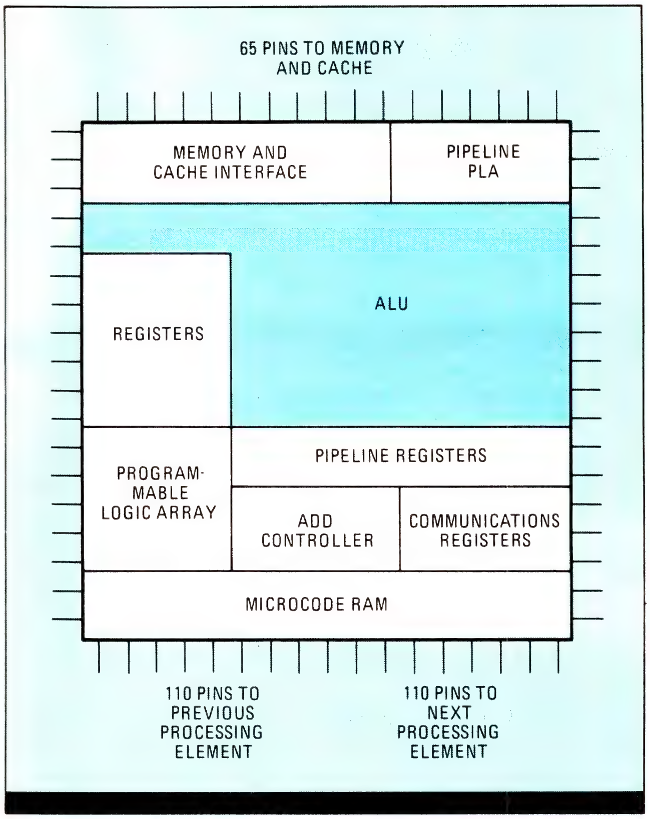
Britain gives it a go

Sensing a lack of resolve and interest in the area in the near term by U.S. companies, three UK firms have entered into a coordinated effort with three academic institutions to study fault-tolerant wafer-scale integration. Over the next 3½ years, submicron CMOS parts will be produced to demonstrate various solutions to the design problems. Estimated to cost about $2.8 million, the program represents the first step by the British in an attempt to gain an edge in what they consider to be the technology of the 1990s.

The Plessey Co. plc is managing the project. Plessey's industrial partners will be the General Electric Co. plc's Hirst Research Center and International Computers Limited plc. They in turn will be collaborating with Brunel University at Uxbridge, Middlesex Polytechnic in North London, and King's College, University of London. The objective of their work is to develop fault-tolerant design techniques for use on two types of wafer-scale circuits—one with a regular array structure and the other a nonregular, cell-based type.

While most of the UK electronics companies are banding together to fund research, Sinclair Research Ltd. is going it alone with plans to launch its first wafer-scale product in the fourth quarter of 1985. Used as a small-capacity Winchester-drive replacement in Sinclair's QL 32-bit microcomputer, the circuit contains half a megabyte of serial self-testing and redundant memory, with an estimated access time of 10 to 100 ms, about a hundred times faster than a mechanical disk drive.

According to Mangir Tulin, a specialist in wafer-scale integration and VLSI technology at the University of California at Los Angeles, the focus of most current research efforts in wafer-scale technology is on increasing yields through the use of redundancy and various methods of reprogramming and reconfiguring the links between good circuits (Table 2). At the Massachusetts Institute of Technology's Lincoln Laboratory, Jack Raffel and his co-workers have developed a technique called restructurable VLSI, in which defects are bypassed by laser programming of metal interconnections on finished, pretested wafers. Studies such as Daughton's notwithstanding, Raffel's group aims to fabricate very large random-logic systems on a single wafer, despite the presence of many defects.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COMMUNICATIONS REGISTERS
MICROCODE RAM
110 PINS TO PREVIOUS PROCESSING ELEMENT
110 PINS TO NEXT PROCESSING ELEMENT

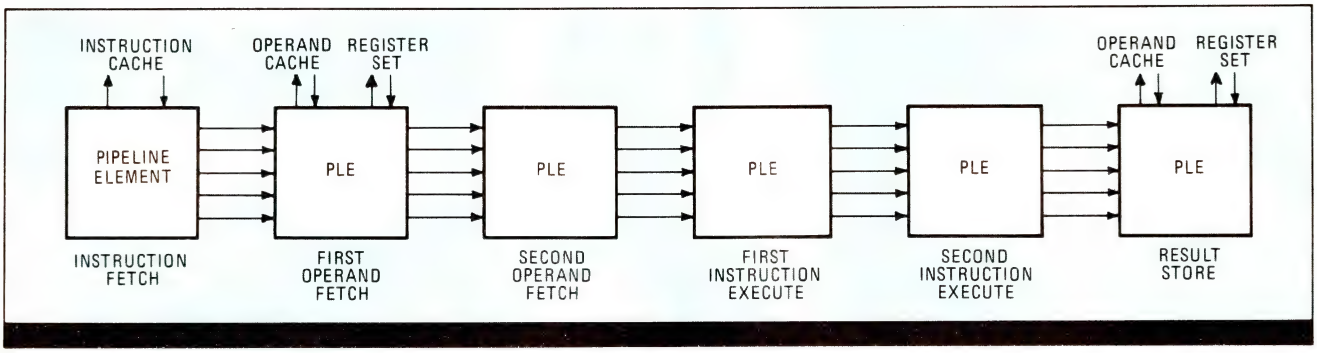
1. Pipeline element. The pipeline element (PLE) is the main building block in GTE Laboratories' pipeline architecture. Multiple copies of the PLE are built on a wafer and interconnected. A microcode customizes each PLE, so it can perform its correct function.

In this approach, an array of random logic and memory cells is embedded in a matrix of programmable interconnections. Each cell is in the LSI range, fabricated with 5-μm CMOS. The individual die size is determined by production capability to keep yields within 50% to 70%. The first application of this restructurable VLSI methodology is a digital integrator containing 130,000 transistors. The wafer contains 192 cells, of which 64 must be usable to build the system.

FFT system in works

Now under development at the laboratory is a more ambitious wafer-scale project: a 16-point fast-Fourier-transform system, containing 300,000 transistors, that can perform 1 million 16-point-by-16-bit transformations per second. Future efforts are aimed at achieving systems with about 10 million gates per wafer.

Because they consist of numerous, identical processors, various non-von-Neumann architectures appear to be ideal for implementation as wafer-scale systems. One class of non-von-Neumann systems that appears to be receiv-



2. Lined up. Pipeline elements are interconnected serially to form a complete single-data-stream pipeline processor. Each PLE uses its input/output pins differently in order to implement the operation of the complete processor.

ing a great deal of attention at research centers around the country are systolic arrays that employ a large number of simple processing elements.

At the University of North Carolina at Chapel Hill, Kyle Hedlund is investigating the use of a two-level approach for structuring a wafer-scale systolic-computing system containing over 500 individual processors per 5-in. wafer. A prototype of this system, called the WASP (for wafer-scale systolic processor), is currently being fabricated in a wafer organized into a two-level hierarchy. At the first level are the processing elements, which are fabricated using a 1-μm n-MOS process. These are organized into building blocks of 12 processing elements each, only four of which have to be operable.

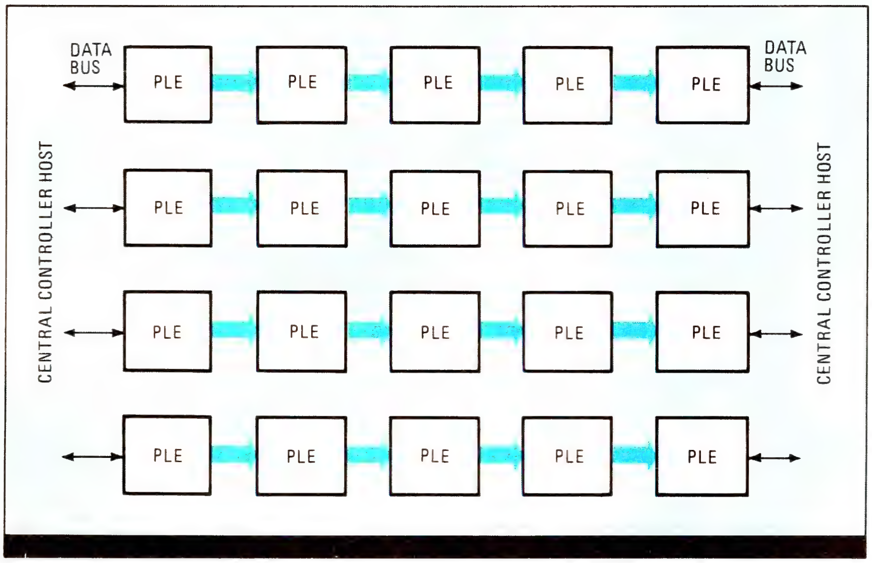
The building blocks are then organized into a mesh or grid on the wafer. After restructurable wiring techniques link each processing element within each building block, the processors are tested. The wiring is then customized to define the connections between functional processing elements and to route around the faulty ones. Programmable switches inserted into the wiring channels store a setting that specifies one or more incident data paths. Since the area required for the data paths and switches requires no more than 15% of the total wafer area, switch yield is about 99%.

A different tack is taken to ensure operation of each building block. Rather than requiring that each building block be completely functional, the design allows each 12-processing-element block to have only a 2-by-2 mesh to operate. Block-recovery analysis by Hedlund indicates that with 12 processing elements per block, at least 99% of the blocks will have at least four good processors.

Attractive as non-von-Neumann architectures are for wafer-scale implementation, conventional pipeline multiprocessor architectures such as single-instruction single-data or single-instruction multiple-data machines can also benefit, according to Jeff Fried, a corporate researcher at GTE Laboratories, even though they require a number of different types of functional elements. By proper partitioning, however, most conventional architectures can be constructed with no more than three different basic building blocks—storage-control elements, pipeline elements, and arithmetic elements. Although not as simple as a systolic array with only one type of element, such partitioning makes it possible to implement conventional pipeline computers at the wafer-scale level.

The central building block in Fried's design is a general-purpose, self-testing, 32-bit pipeline element (PLE). Multiple copies of this PLE are built on a wafer, connected to each other and customized through microcode. In a typical system, one PLE might perform instruction-fetch functions while another might perform instruction execution. The PLE contains a high-speed sequencer, a microcode RAM, a 32-bit arithmetic logic unit, storage and status registers, and custom pipeline-control hardware (Fig. 1). It has a large number of interrupt lines to allow for fast communication of pipeline interlocks, cache status, and other critical information. Each of these elements has a special programmable logic array, which controls the microsequencer according to its system function.

A number of conventional pipeline processors, either single- or multiple-data types, can be built using this basic PLE, says Fried. Each PLE in such a system would have a different microcode and would use its I/O pins differently. In a conventional

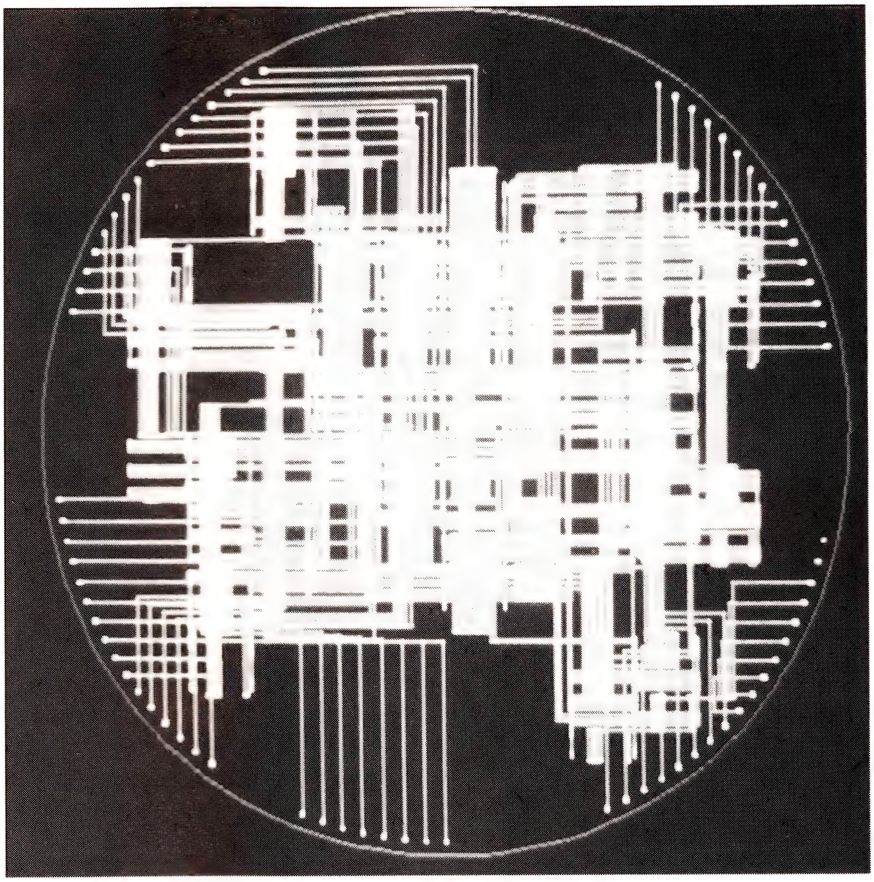


3. Multiple pipelines. In the multiple-data-stream architecture, the pipeline elements are connected in four parallel paths. Each PLE is encoded with its own microcode and uses this information to enable the entire system to operate as a processor.

single-data-stream pipeline (Fig. 2), some of the PLEs would use their cache memory to access registers or cache; others would not. In a multiple-data-stream architecture, PLEs would be configured into four parallel pipelines (Fig. 3).

To achieve reasonable yields per wafer, Fried uses a combination of redundancy, self-testing, and restructuring around faulty circuitry. In each PLE, all hardware is accessible to the sequencer, which first tests itself and then each part of the circuit. Only if all the hardware is working is a special Use line turned on, tying the PLE to the I/O lines of the previous and next PLEs. If the PLE line is faulty, the Use line will not be active and the interconnection wire will proceed to the next PLE.

An electron-beam-programmable switch is also provided on each PLE should a fault in the interconnection wire or PLE make normal test and connection erroneous. Each of the specialized pipeline, storage-control, and arithmetic elements—fabricated using a 1.2-μm silicon-gate CMOS process—requires about 150,000 transistors and fits on a 200-mil^2 chip. At a yield of only one out of three working processors, a 3-in. wafer would yield about 20 processors available for connection into a pipeline, says Fried.



4. Routed wafer. A computer-aided-design discretionary-wiring router program produces wiring about 25 times finer than the wiring required to interconnect the same dies on a printed-circuit board. This enables the implementation of functions such as the fast Fourier transform.

At Rensselaer Polytechnic Institute's Center for Integrated Electronics, researchers are working on implementing a wafer-scale multiprocessor architecture that can compute two-dimensional fast Fourier transforms on a 256-by-256-pixel image at a rate of 30 images a second—equivalent to performing 63 million 16-bit fixed-point multiplications/s (Fig. 4).

Bypassing the problems

The one method that appears to bypass all the problems associated with traditional wafer-scale integration is the hybrid approach developed by Mosaic Systems. In essence, what the firm has done is separate the problem of interconnection reliability and yield from the problem of die reliability and yield.

This was done by using a 100-mm-diameter electrically programmable interconnection wafer as the passive interconnection network for pretested chips, which can be bonded to it hybrid-style. Its unique advantage is that the interconnection pattern can be electrically field-programmed, eliminating the need for a custom mask for each application, says Robert Johnson, Mosaic president and founder. Local defects on the wafer relating to the interconnection can be avoided by simply programming alternative routes around them.

"In a typical application, several thousand out of a total of 1.5 million antifuses must be fired," says Johnson. The bonding pads serve as access nodes for the programming, which requires less than 1 ns per antifuse. With two layers of signal wiring separated by amorphous silicon, one wafer can provide about 2,000 in. of interconnection wiring per square inch of substrate. Depending on the size and pinout of the chips used, up to 200 dies can be bonded onto one 4-in. interconnection wafer. This allows interconnection and packaging of up to 32 fully populated 4-in. wafers in about 8 in.^{3} without significant propagation delay.

To achieve essentially the same performance with CMOS that Trilogy was trying to achieve with emitter-coupled logic, Johnson and his research team at Mosaic are combining their hybrid-interconnection-packaging wafer technology with a cooling system that allows operation at liquid nitrogen temperatures. Propagation delays across a wafer at liquid nitrogen temperature are about 500 ps, about equal to that of a typical CMOS gate at ambient temperatures.

Johnson estimates that an entire supercomputer could be put on one such wafer with just 40 CMOS chips, each containing the equivalent of 20,000 gates. A number of researchers agree that if the wafer-scale efforts by Mosaic and Inova prove to be cost effective, the companies have only about a year's lead time before established semiconductor firms move into the marketplace with similar parts. ☐

Bernard Conrad Cole is an editorial consultant, author, and science writer.

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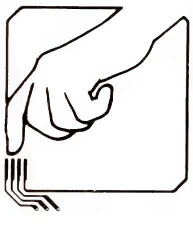

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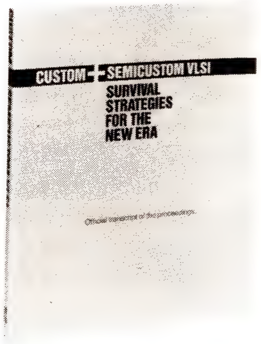

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COMPUTERS GET IT ALL TOGETHER

CIM, which combines a myriad of manufacturing processes, is pointing the way to the factory of the 21st Century

☐ *by Lawrence Gould*

Seven technologies are crucial for computer-integrated manufacturing, says Thomas G. Gunn, corporate vice president and manager for CIM at Arthur D. Little Inc., Cambridge, Mass.: computer-aided design, group technology, manufacturing planning and control systems, automated materials handling, computer-aided manufacturing, robotics, and computing technology. Through these, CIM provides computer control or aid to all production and business functions, including marketing, forecasting, and accounting.

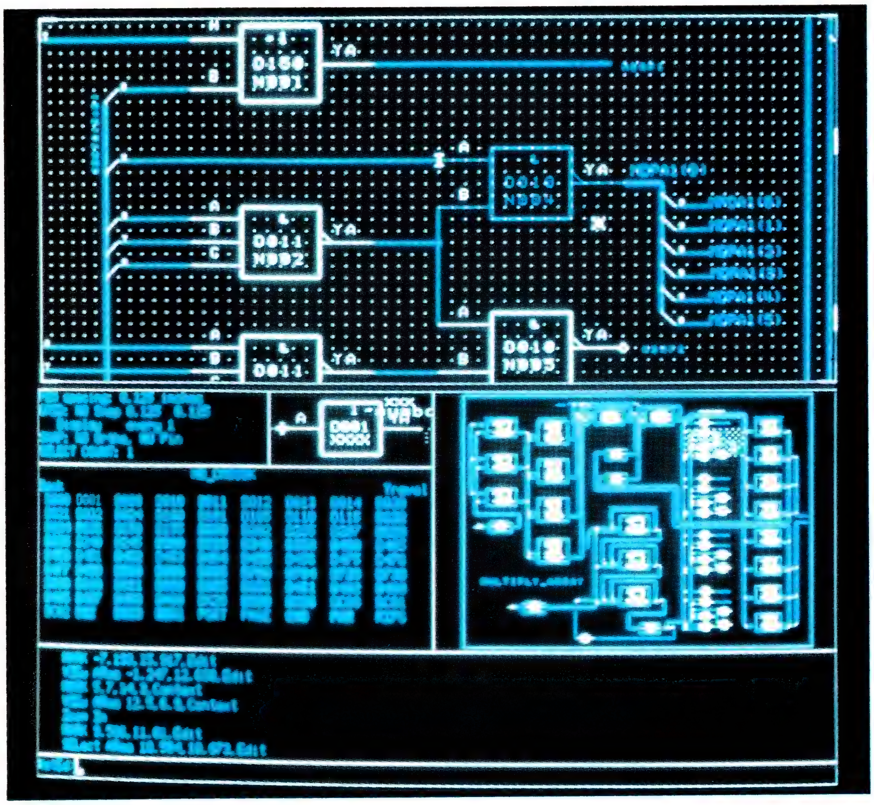
A product begins at the design stage—CAD, which is probably the fastest-growing technology in CIM. Actually, CAD consists of four technologies, which the engineer uses to design, analyze, and test objects, and to determine how they'll be built:

- CAD—design and drafting.
- Computer-aided engineering—test and analysis.
- Computer-aided process planning—machine and production scheduling.
- Numerical-control part programming—n/c tool program creation.

During the design of a circuit, CAD typically results in a three to fourfold increase in productivity. More important, CAD and CAE make a whole new class of products available. In the days of breadboards, very large-scale-integration circuit design could not be accurately duplicated, tested, and analyzed. Now, however, CAE can simulate a VLSI design under real operating conditions, without building the chip. Control Data Corp.'s Modular Integrated Design Automation System (Midas) is one example of this process [*Electronics,* June 28, 1984, p. 52]. If the design should fail, it can be readily and quickly changed and retested (Fig. 1).

CAD can also create enormous cost reductions in manufacturing and service. The process enables the designer to utilize a single chip to replace an entire circuit board full of off-the-shelf discrete components, according to Bill Jaques, general manager of electronic CAD at Control Data. Manufacturing circuit boards typically costs $2,000; a chip, on the other hand, can be produced for only $50.

CAD also helps create finished chip products that are



1. CAD and CAE. Circuit logic can be created on Control Data Corp.'s modular integrated design-automation system. Through simulation, the circuitry's performance can be predicted. The system's shared data base is compatible for both design and simulation.

faster, more reliable, and simply better. "If you can cram a whole board of components into a single chip," explains Jaques, "then the chip will operate faster because propagation delays are shorter." Using CAD, Intel Corp. reduced the mask design defects in its 256-K high-density memories by 84%, despite the fact that the complexity of the chips had been sharply increased. Computer-aided process planning also has a variety of benefits (table), particularly in standardizing routings, optimizing process utilization, and reducing introduction costs for new parts. For example, automating process planning has a significant effect at IBM Corp.'s plant in East Fishkill, N.Y., where a chip goes through more than 300 processing steps between the initial growing of the crystal until it is finally shipped.

Group technology provides organization

Group technology is a methodology as well as a concept. It is a method for organizing and coding both part and circuit designs and their production processes. Group technology reduces the number of designs in the data base; thus it can reduce the circuit-design effort and the lead time for new products.

A chip is usually loaded with hundreds of gate arrays, so automating the process of choosing predesigned circuits can be valuable. Some users estimate that group technology has reduced design costs by as much as 10%, reduced setup time by up to 40%, and increased capacity utilization by up to 15%. Its acceptance has been limited, however, because it requires a huge initial effort and cost to establish a comprehensive classification and coding system. It also vastly changes the way a company designs and manufactures its products.

Gunn of Arthur D. Little defines manufacturing planning and control systems (MPCS) as the systems that "plan and schedule manufacturing operations, allow production and material schedulers to explore alternatives, update shop-floor data, allow operations to be monitored against plan, and allow operating results to be projected. MPCS is probably the broadest and most advanced element of CIM." Such systems have several elements.

First, they incorporate manufacturing resource planning, which is a comprehensive simulation of all manufacturing activities, including business and production planning, inventory control, capacity planning, shop-floor control, purchasing, and cost accounting. There is distribution resource planning, a scheduling and control method that uses manufacturing-resource-planning time-phased techniques to monitor the finished products in a distribution network. Decision support systems enable users to process data as needed to solve problems. The system of shop-floor control captures data from the shop floor and provides machine- and labor-scheduling tools. And there is simulation, which is a computerized model for analyzing any aspect of the manufacturing operation.

BENEFITS OF COMPUTER-AIDED PROCESS PLANNING

Method	Savings (%)
Process planning	58
Direct labor	10
Material	4
Scrap and rework	10
Tooling	12
Work-in-process	6

SOURCE: ILLINOIS INSTITUTE OF TECHNOLOGY RESEARCH INSTITUTE

Manufacturing resource planning helps a manufacturer to determine what to make, what it takes to make it, what is on hand, and what else is needed. In electronics, where a typical system can contain thousands of parts in silicon, metal, plastic, and wire (all coming from a variety of sources with a variety of lead times), manufacturing resource planning can be a godsend in planning and scheduling.

Of the 12,000-plus manufacturing resource planning systems operating today, however, less than 20% have been implemented successfully. These successful installations, though, have recorded typical reductions that have gone as high as 33% in inventory, 25% in indirect labor, 50% in overtime, 15% in manufacturing costs, and 5% in purchased-parts cost—not to mention increases as high as 25% in assembly productivity and 90% in on-time deliveries.

Another system, shop-floor control, is crucial to the efficiency of manufacturing resource planning. This tracks the progress of work orders through manufacturing and closes the loop between the shop floor and upper management. For starters, the ideal shop-floor control system tracks jobs through production to shipping, provides job-status reports, reschedules jobs according to pre-established priority rules, identifies work centers with too much or too little work capacity, and collects time and attendance information. Unfortunately, current shop-floor control systems, though prevalent, lack real-time control and analysis software. And though distribution resource planning is just now proving itself and being accepted, decision support systems and simulation are still in development.

Movement of information and materials

Along with information handling comes materials handling. Automated materials handling combines computers with such conventional materials-handling systems as lift trucks, conveyors, and so on. Although these conventional systems will always exist, even in the CIM environment, there will also be a prevalence of automated storage and retrieval systems, automated guided-vehicle systems, and pick-and-place robots. At the Wang Laboratories Inc.'s plant in Lowell, Mass., wire-guided vehicles rove about the facility picking up and delivering parts, subassemblies, and finished computer terminals. The fact that fabrication occurs on three floors does not stop the vehicles from moving about.

At IBM's East Fishkill plant, silicon wafers glide on a cushion of air from work station to work station. Robots gently pick up the wafers and dip them into cleaning baths or etching solutions, or position them to be worked on by electron-beam tools (Fig. 2). To track materials, a variety of automatic identification systems is available. Foremost among them are the systems using bar codes—the ubiquitous language of moving materials.

Tandem Computers Inc.'s facility in Austin, Texas, has gone one step further. There, all bare boards are identified with a bar-code label. However, the mother-

2. Automated handling. IBM Corp.'s East Fishkill, N.Y., plant uses a robot to lift a wafer off an air track and dip it into a cleaning solution. This monotonous job, boring to humans, is performed repeatedly, reliably, and unfailingly under the computer's control.

board in Tandem's terminals is special. After it is populated with components and passes functional testing, the automatic testing equipment downloads the board's identification number to a nonvolatile random-access-memory chip on the board itself. From then on, all part and subassembly identification numbers and testing histories associated with that terminal assembly are loaded into the RAM for a permanent, electronic traveler.

CAM at the core

Computer-aided manufacturing systems ideally take the numerical data produced by CAD and put it in a form that can be used by the computer-n/c tools, whether they are stand-alone tools, distributed-n/c systems, flexible manufacturing systems, or flexible assembly systems. "In a sense, CAM is the technology for which all other CIM technologies were created," says Gunn. But though CAD and CAM should be used together, most plants have CAD only.

CAM includes machine tools—typically, drilling machines, optical and electron-beam tools, automatic component-insertion equipment, and automatic inspection and test equipment; automatic assembly, a type of machine tool that can feed and position parts and subassemblies, then perform such operations as fastening, crimping, forming, and metering; and process controllers—programmable logic controllers, single-board computers, and microprocessors.

CAM features vast machine-tool program storage; automatic program downloading, uploading, and control; feedback to other systems on production cycle counts, downtime, and so on; and volume and design flexibility. Still, though CAM embodies the control hierarchies for computer n/c, distributed n/c, and the flexible assembly system, less than 5% of the machine tools operated in the U.S. in 1982 were n/c tools. Today, almost all of the machine tools sold are based on computer n/c.

CAD/CAM's benefits can be striking. Again at IBM in East Fishkill, an optical photolithographic process was used to etch bit patterns on read-only-memory chips. Today, the automated electron-beam tool linked with IBM's design facility in Poughkeepsie, N.Y., has slashed fabrication time from almost eight weeks to 10 days. Similarly, Progressive Blasting Systems Inc. has eliminated 90% of the assembly errors because its machining centers operate in a distributed-n/c system, rather than from paper plans that could be inaccurate.

Because of the surge in electronics CIM, automated assembly equipment, once rigid and inflexible, is now being designed and implemented to accept families of electronic parts. In time, robot technology will improve to the point where assembly will be done by robots, thus increasing production flexibility.

Controlling this equipment, at least at the machine level, is the responsibility of the programmable logic controllers—general-purpose, sequential, industrial controllers. These controllers are used for everything from controlling individual computer-n/c tools and other automated devices to controlling entire production lines. As with all computer equipment, programmable logic controllers are featuring more and more intelligence and memory, faster processing speeds, more input/output capabilities, and standardized interfaces—all at ever-decreasing cost.

At the low end of industrial control are the single-board computers. However, some of these computers are complete systems and include a central processing unit, memory, a display, a floppy-disk controller, and serial I/O. "Most SBCs are found in industrial automation," explains Francis Siu, president of Mostron Inc. "Because of their low cost and, in our case, IBM compatibility, SBCs are finding their way into data collection and concentration, robot control, materials handling—anywhere that a requirement exists for inexpensive, intelligent, real-time data gathering and process control."

Automatic inspection and test equipment is approaching the status of a computer-n/c tool. New real-time coordinate-measuring machines, circuit-board and subassembly testers, and better sensors all around are finding their way into distributed-n/c systems.

Revolving carousel

At Tandem, a large, revolving carousel outfitted with burn-in chambers automatically burns in and tests terminal assemblies for 24 hours, while providing a handy storage area and buffer zone before finished assembly. At IBM in East Fishkill, a new facility that is big enough to hold four jumbo jets features dozens of automated test systems that use software control, sensing devices, and robotic arms for testing thousands of VLSI chips every day (Fig. 3). The test systems generate up to 100 million test signals per second and use up to 640 I/O pins to perform functional tests on logic and memory chips at various temperature and power ranges.

"A robot is an n/c machine tool with elbows," explains Richard Morley, director of advanced technologies at Gould Electronic Systems Inc., Amherst, N.H. While companies such as Hewlett-Packard, IBM, and General Electric are using robots to make everything from pc boards to computers to typewriters to meters, robots are still in the development cycle. Research is still required in the areas of robotic programming languages, grippers and end effectors, and feedback-control sensors.

Robots can range from simple materials-handling pick-and-place machines to complex assembly and inspection robots with vision and tactile sensors. Unlike other machine tools, robots are virtually useless as stand-alone units; they need to be integrated with automated materials handling and computer control. However, as with tools for computer n/c, robots provide high labor productivity and reliability. Moreover, they can substitute for humans in hazardous or monotonous jobs.

Computer technology is the glue that connects all the other technologies so that CIM can exist. It includes not only hardware and software but also systems to manage the data base and telecommunications to move that data to where it's needed. CIM includes the gamut of computer hardware, from mainframes and 32-bit minicomputers to programmable logic controllers, single-board computers, and even individual VLSI chips—each selected, integrated, and optimized for the application to which it is dedicated.

In software, CIM will require CAD, group technology, manufacturing resource planning, and much more applications software for accounting, decision support, simulation, shop-floor control, maintenance, and so on. Standardized, transportable, real-time, multitasking operating systems, which AT&T Bell Laboratories' Unix operating system is supposed to address, will be a must. Natural languages will exist so that users with no programming expertise can generate their own applications software. And heretofore dedicated data bases will be combined into one that contains both alphanumeric data and information on parts and circuit design.

Networking

In addition, CIM will require a three-tiered telecommunications network to match the different types of information required for manufacturing management: corporate, facility, and cell-wide information. Recently, much of the CIM market activity has been in cell-level local-area networks. At last year's National Computer Conference, nine companies participated in a working network that followed the Manufacturing Automation Protocol (MAP) specifications (IEEE 802.4) developed by General Motors Corp. [*ElectronicsWeek*, Feb. 18, 1985, p. 21].

"MAP is truly groundbreaking," says Ken Miller, president of Concord Data Systems Inc., one of the few vendors of MAP-compatible LANs. "MAP is the first LAN standard driven by a user. In this case, GM doesn't want proprietary solutions, proprietary LANs. Industrial automation is a multivendor environment. MAP ensures that we have not only data transportation but also the assurance that devices at all nodes speak the same language. At the NCC, you could see an IBM talking to a DEC talking to an HP talking to a Gould or Allen-Bradley."

Communications in CIM will always be an issue: after a certain level of automation, the ability to network this hardware together becomes an absolute necessity. Therefore, all computer hardware will be required to conform to standards. This means that not only must the physical interconnections conform but also that the hardware will have to include the communications board for easy interfacing and LAN communications.

This is already happening. Allen-Bradley's Vista 2000 supervisory controller both monitors and controls up to 5,000 programmable logic controllers. In addition, it communicates through the built-in LAN interface provided by Concord Data Systems to any other computer that is compatible with IEEE 802.4. In operation, a broadband network connects the plant's host computer to the Vista 2000. Below that level, Allen-Bradley data highways serve the communication and control needs of programmable logic controllers, computer numerical controllers, and other automated devices.

Today's CIM comes in varying degrees of sophistication. Gunn estimates that factory automation will average a 14% annual growth, from an estimated $34 billion in 1984 to $98 billion by 1992. Hewlett-Packard Co.'s Mike Galane projects that 10% to 15% of that latter figure will be spent by the electronics industries and industries with significant electronic content, such as aerospace, communications (modems, private branch exchanges, satellite links, and switchers), optical disks,

3. Automated test equipment. To check a wafer full of very large-scale-integration chips, IBM uses a 100-MHz tester. The system generates up to 100 million test signals per second and takes less than 10 minutes to test over 200 computer chips.

copying machines, automotive equipment, and environmental control systems. If the CAD market is typical of the entire CIM market, then electronics may swallow up to 25% of the CIM expenditures.

But someone has to supply all this equipment, technology, and, particularly, integration expertise. Though many companies would like to, only a few, if any, can supply the entire CIM plant. Products from Digital Equipment Corp., General Electric, HP, and IBM make up most of the pieces of the CIM pie. In addition, all four can market the experience and expertise gathered in implementing CIM in their own facilities. DEC, for example, has 17 CAD/CAM centers throughout the world that are being used to provide a range of resources, including the latest developments in engineering and manufacturing computing, customized products, technical education, software and consulting, and flexible maintenance services.

Aggressive embrace

"However, we can't be all things to all people," says Galane. "We can't provide all the solutions. There is no generic factory. Therefore, we need support from system integrators, original-equipment manufacturers, independent software vendors, value-added resellers, and so on. At one time, we thought we were competing with these companies. Now, we find we can't get along without them. In fact, we are embracing them—aggressively."

The system integrators are the new breed of CIM vendor. "A system integrator will tie these systems together," explains Robert Tomich, manager of HP's systems-integration program. "You've got both the vertical integration in a factory, which requires your manufacturing-oriented people, and horizontal integration, which requires your software-oriented people.

"The systems integrators will be the go-betweens—they'll integrate facilities, computer-numerical-control tools, programmable logic controllers, materials handling, and other systems. System integrators are faster than the vendors. They're entrepreneurial. They're creative. They have a variety of skills. They don't have the R&D equipment overhead. And teaming up with them is a win, win, win situation for the buyer, the computer vendor, and the integrator."

There aren't many system integrators around—there may be only 15 in the industry who can handle an entire CIM project. And they have their specialties: Logitek, in Troy, Mich., for instance, specializes in automotive CIM; Thesis, in Dallas, specializes in CIM for integrated circuits; and Systems Control Inc., Palo Alto, specializes in electronics. Regardless of who supplies the integration, most of the technology for CIM has already been developed—it is mature and available. The only thing that's left is the commitment to start. ☐

This is the second part of a two-part special report.

Lawrence Gould is former director of research at The Yankee Group (Boston) in the factory-systems planning service.

CARDS DO GRAPHICS FAST

Featuring multiported display memories for quick and easy access, a pair of graphics controllers for IBM PCs paints screens quickly ☐ *by Steve Zollo*

Designers in search of more colors and faster displays will find what they are looking for when the Number Nine Computer Corp. introduces the two color graphics controllers at the National Computer Graphics Association show later this month. Targeted at such high-performance applications as computer-aided design, business graphics, and medical imaging, the Revolution 512 × 32 provides a resolution of 512 by 512 by 32 pixels and the Revolution 1024 × 8 provides a resolution of 1,024 by 1,024 by 8 pixels.

To be used with the IBM Corp. Personal Computer, PC/XT, PC AT, and their compatibles, the cards can contain up to 1 megabyte of memory. The memory is multiported, so that both the computer's CPU and the graphics board's NEC 7220-based processor can access it at the same time. This lets images be built more quickly, says Will Frentz, marketing vice president. Each board has three color lookup tables, one for each of the monitor's three guns.

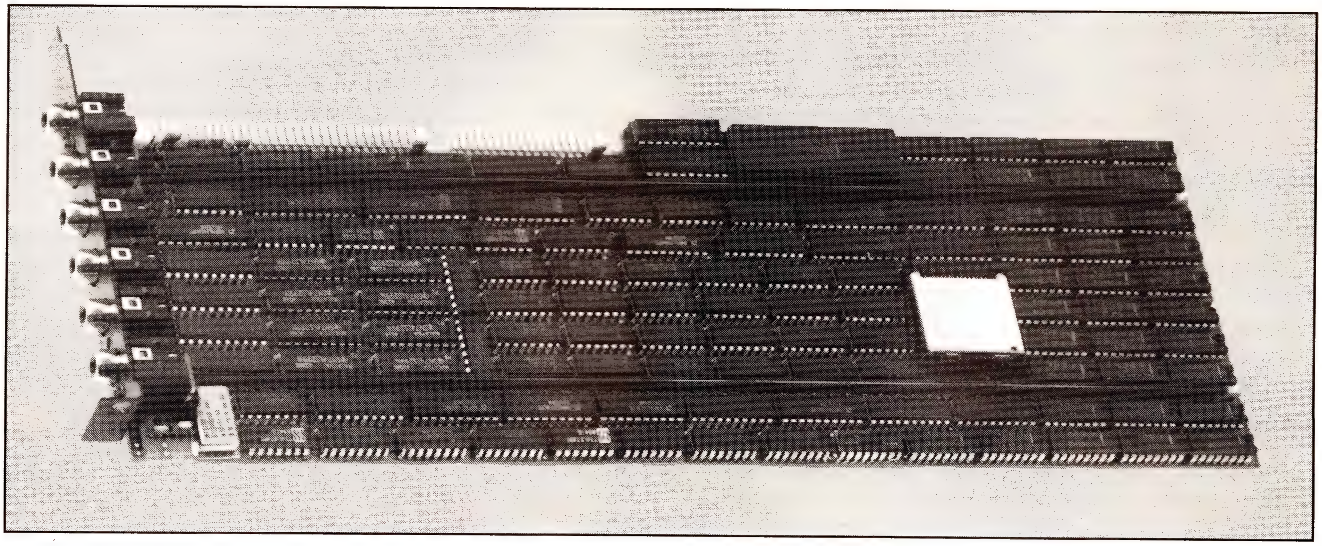
"The boards represent a significant memory extension in the Revolution graphics-board family. The original Revolution board [512-by-512-by-8-bit version] is not being displaced. It is instead now one of a series of graphics boards that provide a wide range of color and resolution configurations. System architecture throughout the family is consistent, ensuring software compatibility," Frentz says.

The high-resolution board, the 1,024-by-1,024-by-8-pixel unit, can display as many as 256 colors simultaneously from a palette of 16.8 million. Three 1-K-by-8-bit read/write lookup tables are used. The card draws pixels at a rate of 40 MHz.

The board, which draws just 2.6 A from a 5-V supply, uses a pixel mode for reading and writing. In the pixel mode, the board accesses the display buffer one pixel per byte at a time, allowing high-speed screen updating. From hardware, the board can draw vectors, circles, and other polygons in the pixel mode.

The board produces red-green-blue analog, 30-Hz interlaced, or 60-Hz noninterlaced signals. When driving a 60-Hz noninterlaced display, resolution drops to 832 by 624 pixels. As an option, the board can put out National Television Standards Committee signals.

The lower-resolution board, the 512-by-512-by-32-bit model, offers a number of screen writing modes. Besides the pixel mode, the board has an RGB-gun mode, in



which the board accesses a display buffer one gun at a time so that primary colors or overlays can be updated at high speed. In the concurrent mode, the board writes the same value to the red, green, and blue display-buffer areas for full emulation of the firm's earlier Revolution 1108 board.

With its 32-bit deep planes (8 bits per color gun, plus two 4-bit overlays), the board offers a choice of 16.8 million colors, of which 262,144 can be displayed simultaneously. The pixel rate is clocked at 10 MHz.

Hardware features include from 1× to 16× zoom, panning, and scrolling. The board can drive an RGB analog or a 30-Hz interlaced monitor; NTSC driving is optional. Available now, the Revolution boards sell from $1,500 to $5,000, depending on the model and memory.

Users will be able to write software in any of the three most popular graphics-development environments—VDI, NAPLPS, and GKS.

Frentz points out that the Revolution cards are high-performance cards, not replacements for IBM's own graphics adapter and other low-performance cards designed to run software such as Lotus 1-2-3. According to Frentz, last year's market for graphics cards of all performance levels was over 10,000 pieces. Number Nine anticipates $4.5 million in sales this year, up from $1 million last year.

Number Nine Computer Corp., 691 Concord Ave., Cambridge, Mass. 02138. Phone (617) 492-0999 [Circle reader service number 338]

CMOS gate arrays boast minimum propagation delays

Using 3-μm silicon-gate CMOS technology, a family of high-speed digital gate arrays ranges in size from 150 gates for simple logic replacement to 2,600 gates for more complex system solutions.

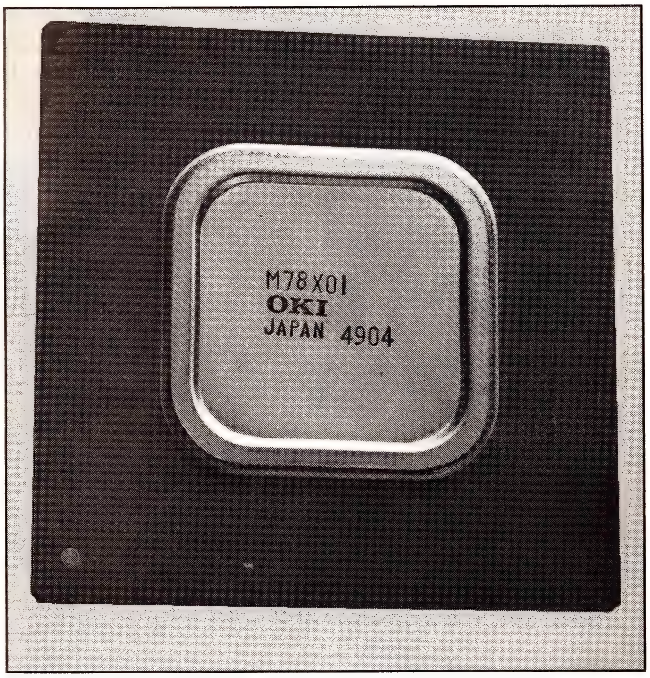
The arrays use a single-metal process and are designed to permit programmable gate contacts for increased flexibility and minimum propagation delays. Output buffers are provided that will drive up to three TTL loads. Typical propagation delay for a two-input NAND gate is 1.4 ns; a D-type flip-flop may be toggled in excess of 40 MHz.

Available in DIPs and other packaging configurations, prices start at $2.50 for a 150-gate array. Depending on the complexity of a design, delivery takes from 8 to 16 weeks for prototype quantities. A five-day training course on the Mentor work station, which may be tailored to customer applications, is also available.

Array Technology Inc., 1297 Parkmoor Ave., San Jose, Calif. 95126. Phone (408) 297-3333 [Circle 342]

Array with 10,008 gates can be a one-chip system

Like a blank canvas, a 10,008-gate CMOS array provides design engineers with a tool from which they can build entire systems. Using 2-μm design rules, the dual-layer silicon-gate part can be programmed as a system on a chip, resulting in lower manufacturing costs and power consumption and lighter, smaller power supplies, the company says.



Designated the MSM78H000, the array measures nearly 400 by 400 mils and was developed for use in 32-bit systems requiring memory, logic, bus, and system-bus controllers. Each of the MSM78H000's gates, called unit cells, consists of two pairs of transistors, each pair comprising a p-MOS and an n-MOS transistor. Unit cells are arranged in an array of 278 columns by 36 rows. The MSM78H000 features a typical propagation delay of 2.3 ns and operates at 40 MHz from 3 to 6 V. It is capable of operating in temperatures from –40°C to +85°C, and both CMOS and TTL compatibility are featured on the I/O ports.

Also featured is a cell library consisting of 82 functional blocks and 38 macro blocks. The array is available in ceramic pin-grid arrays and 84-pin plastic leaded chip carriers. In the latter package, the parts cost less than $100 when purchased in high volume. Delivery takes 16 to 18 weeks from receipt of data-input requirements.

Oki Semiconductor, 650 N. Mary Ave., Sunnyvale, Calif. 94086. Phone (408) 720-1900 [Circle 341]

High-speed multiplier offers 32-bit precision

Delivering 32-bit products in just 50 ns typically, 75 ns maximum, the 16-by-16-bit 74S556 Flow-Thru Multiplier Slice uses ECL circuitry to achieve its high speeds. It is priced significantly lower than its chief rival, Logic Devices Inc.'s LMU18, a CMOS part [*ElectronicsWeek*, March 11, 1985, p. 84].

The high-speed combinatorial fully parallel multiplier can multiply to 16-bit operands in signed and unsigned 2's complement or mixed formats. It produces a full 32-

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Using separate input and output buses, the chip has an output pin for each bit of the product, eliminating the need for multiplexing. It features worst-case power-supply current of 800 mA (600 mA, typical). Latches in the 74S556 increase the throughput rate in pipelined systems. When these are disabled, however, the multiplier functions as a memoryless arithmetic network with a 90-ns worst-case flow-through time for 32-bit products.

The multiplier is available now in either 84-pin leadless chip carriers or 88-pin grid arrays. The PGA part is priced at $108.75 each in quantities of 100 and the chip-carrier version at $135.94.

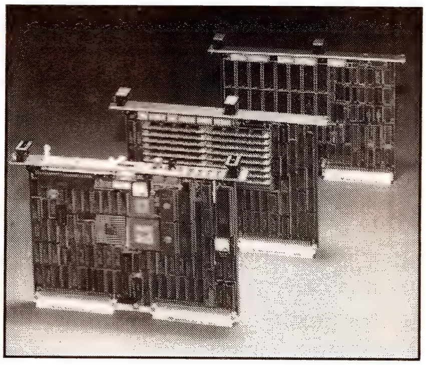
Monolithic Memories Inc., 2175 Mission College Blvd., Santa Clara, Calif. 95054. Phone (408) 970-9700 [Circle 340]

32-bit VME board approaches mainframe computer power

Sustained rates of 2 million to 3 million instructions/s can be attained by the MVME130, a 32-bit VMEbus microcomputer board.

Burst rates over 6 mips are also possible, putting the board in the realm of some mainframe computers. Motorola Inc. built its 68020 32-bit microprocessor into the board, which also has sockets for an optional floating-point coprocessor, designated the 68881, and the manufacturer's Demand-Paged Virtual Memory Management module.

The MVME130 incorporates system-controller functions such as a VMEbus interrupter, interrupt handler, and a bus arbiter. Although the board is designed to operate at a 16.67-MHz clock rate, initial deliveries will implement only a 12.5-MHz clock instead, the company says.



A pair of associated memory boards is dual-ported to both the VMEbus and Motorola's proprietary VMEbus expansion unit, the MVMX32bus. The MVME204 1-megabyte RAM accommodates 32-, 16-, and 8-bit data transfers, with byte-parity generation and checking circuitry to ensure data integrity.

The MVME214 static RAM/ROM module provides up to 1 megabyte of ROM or up to 128-K bytes of static RAM. Sockets accommodate 16 standard 24- and 28-pin memories.

The MVME130 microcomputer is $3,995 in quantities of one to five. The MVME131, which has the memory-management unit, is $4,845. The price for the memory boards is $4,200 for the MVME204 dynamic RAM module, and $1,400 for the MVME214 static RAM/ROM module. VME130bug, a debug and monitor firmware package, is $500. First shipments are scheduled for April, with the product expected to be generally available in June.

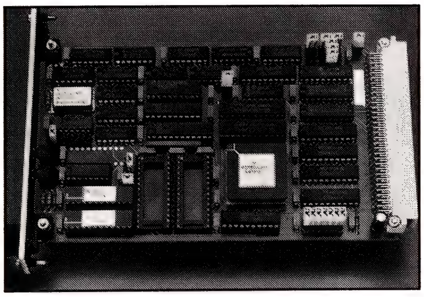
Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Ariz. 85036. Phone (602) 438-3222 [Circle 345]

VME board's cache memory increases throughput

Using a high-speed 1-K-byte cache memory, the MB68K-101 CPU board speeds throughput when accessing main memory.

The central product in a new line of VME boards, the single-height MB68K-101 can be used as a high-performance single-height VME system or as a slave processor in a double-height system. The CPU board is intended for applications in industrial control, robotics, process control, computer-aided design and manufacturing, as well as in test and measurement instrumentation.

Besides cache memory, the CPU board also has 3-K bytes of high-speed RAM, sockets for up to 64-K bytes of EPROM or an additional 16-K bytes of RAM, a bus requester, and an interrupt handler. The board can be based on either the 68000 or 68010 using the 8-MHz, 10-MHz,



and 12.5-MHz versions.

Prices for the board series, which will be available in May, start at $1,095 in quantities above 25.

Microcosm Inc., 14355 S.W. Allen Blvd.,
Beaverton, Ore. 97005.
Phone (503) 626-6100 [Circle 346]

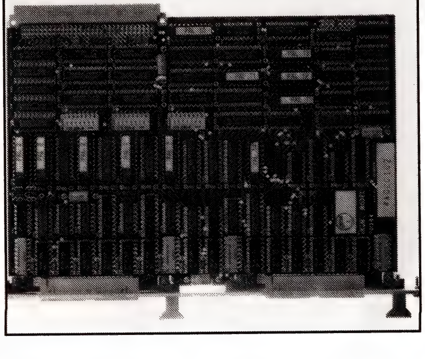
VMEbus board emulates DEC DR11-W interface

A pin-compatible emulation of Digital Equipment Corp.'s DR11-W parallel direct-memory-access interface, the 100N4 VMEbus board can link any product with a DR11-W-compatible interface.

Using DEC-style unified bus transceivers for all external signals, the board provides byte swapping and separate switches for DMA and programmed I/O. The 100084's bipolar, asynchronous, and delay-line driven architecture achieves transfer rates of 2 megabytes/s.

The interface board can be used as an interprocessor link, between VMEbus-based computers and either DEC computers or other DR11W emulation products, according to the manufacturer.

Ordered a single unit at a time, the emulator board sells for $1,550. In quantities over 500 pieces, however, the price falls to $850 each. The company has production quantities available for immediate shipment.



Ikon Corp., 2617 Western Ave., Seattle,
Wash. 98121.
Phone (206) 624-3410 [Circle 369]

Desktop versions of Series/1 use IBM PC ATs, PC/XTs

A pair of two-card inserts transforms either an IBM Corp. Personal Computer AT or a modified PC/XT into desktop versions of the company's Series/1 computers.

The IBM Series/1 5170 model 495 processor consists of a PC AT and two Series/1 cards: an attachment card with ports for peripherals, and a processsor card with Series/1 memory and logic functions. The Series/1 4950 uses a modified PC/XT, the processor card, and a different version of the attachment card.

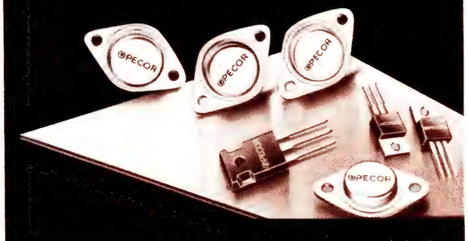
Both use PC keyboards and monochrome displays as system consoles; in addition, up to four display stations can be locally attached. Available only as factory-shipped units, the low-end Series/1s can also be operated as PCs when desired.

Utilizing a new licenced program called Series/1 Input/Output Executive, the IBM PC microprocessor controls I/O for such peripheral equipment as printers or terminals. Both versions rely on the same processor card, which includes 256-K bytes of Series/1 main storage, and can be upgraded to either 384-K bytes or 512-K bytes.

The 5170 model 495 has 512-K bytes of PC main storage, a 20-megabyte fixed disk, and a 1-megabyte floppy-disk drive. It features four RS-422 local ports for connecting display stations, and two RS-232-C asynchronous ports, one of which can be used as a binary synchronous communication port.

The 4950, which contains a four-port host/terminal attachment card, comes in two versions: the model A, with a 10-megabyte fixed disk and a 320-K-byte disk drive, and the model B with a single 320-K-byte drive. Model B can be configured with a second 320-K-byte drive as well as with an IBM 5161 model 3 expansion unit containing two 10-megabyte hard disks.

The 5170 model 495, a PC mono-



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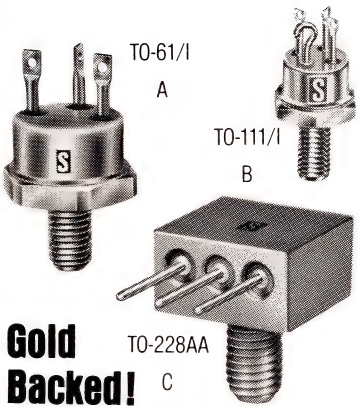

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chrome display, and an associated adapter are priced at $9,420, with limited quantities to be available in November and general availability beginning in 1986. The 4950 model A, configured in the same way, costs $8,130; the model B, in the same configuration and with the 5161 model 3 expansion unit, carries a $10,420 price tag. Shipment for these models will begin in July.

IBM Corp., Information Systems Group, 900 King St., Rye Brook, N.Y. 10573.
Phone (914) 934-4488 [Circle 347]

Enhanced Apple IIe costs the same as old model

Four new chips enhance the Apple IIe personal computer's performance, increase its compatibility with the Apple IIc, and cause only a minimal loss of software compatibility.

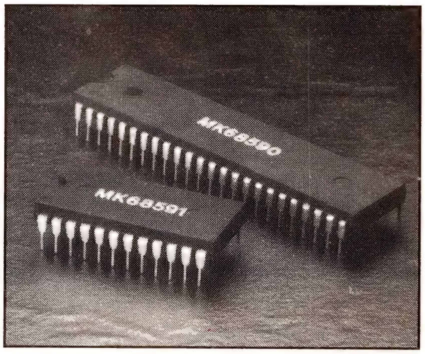
The new chips include the 65C02 microprocessor (the same one used in the IIc), which provides compatibility between the two computers and allows developers to create more efficient software. Also included are a character-generator ROM chip (also from the IIc), which adds support of Apple's MouseText character set, and a pair of revised monitor ROM chips that improve the IIe's mouse response and network support and also enable developers to incorporate print spooling and clock support in their programs.

Over 95% of the software currently available for the Apple IIe will run on the enhanced computer, the company says, and free or inexpensive upgrade programs are available for the few products that won't.

The enhancements, available in all units now being shipped, will have no effect on the IIe's $895 list price. Current Apple IIe owners can upgrade their models with a $70 kit.

Apple Computer Inc., 20525 Mariani Ave., Cupertino, Calif. 95014.
Phone (408) 996-1010 [Circle 348]

Chip set simplifies interface with 16-bit microprocessors



Compatible with both Ethernet and Cheapernet, the Eithernet chip set simplifies the interface between a 16-bit micro- or minicomputer to either local-area network. Using the n-MOS MK68590 Lance (for LAN controller for Ethernet) and the MK68591 serial-interface adapter, designers can save up to 75% in board real estate and costs when implementing an Ethernet protocol.

A general-purpose parallel system interface for both memory and processor and a direct serial interface to a clock encoder/decoder are built in. With them, the node controller can interface easily with all major 16-bit microprocessors, including the 8086, Z8000, and LSI-11 as well as those built by the manufacturer. Full 24-bit addressing, which allows a 16-megabyte address space, and a diagnostic system at both the chip and system levels are also offered.

The Lance's on-chip direct-memory-access controller enables it to simplify the transfer of message packets between the chip and the network link; a built-in 48-byte first in, first out terminal provides efficient system DMA transfers. Both daisy-chain and sole-requester configurations are supported.

The Lance comes in a 48-pin ceramic package and sells for $74.50 each in quantities of 100 or more; the serial interface adapter sells for $25.30 each in 100-piece quantities and comes in a 24-pin ceramic package. Samples are available now.

Mostek Corp., 1215 W. Crosby Rd., Carrollton, Texas 75006.
Phone (214) 466-6000 [Circle 349]

Disk subsystem supports real-time image processing

With transfer rates up to 9.3 megabytes/s, the Concept 21 high-speed disk subsystem can assist in real-time image processing and data communi-

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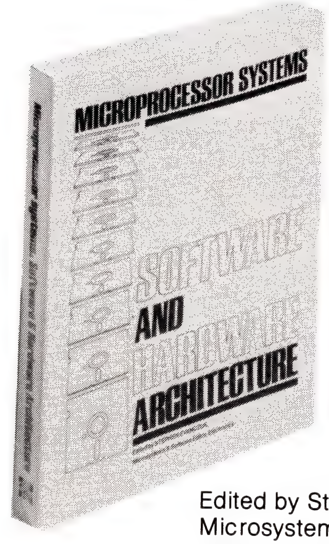

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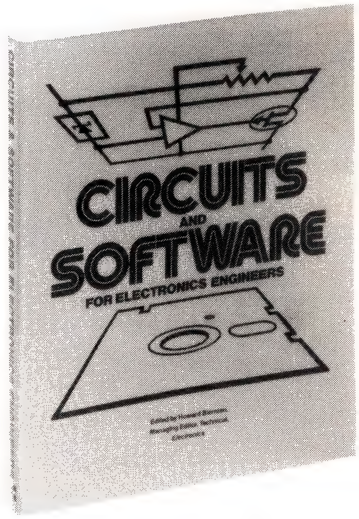

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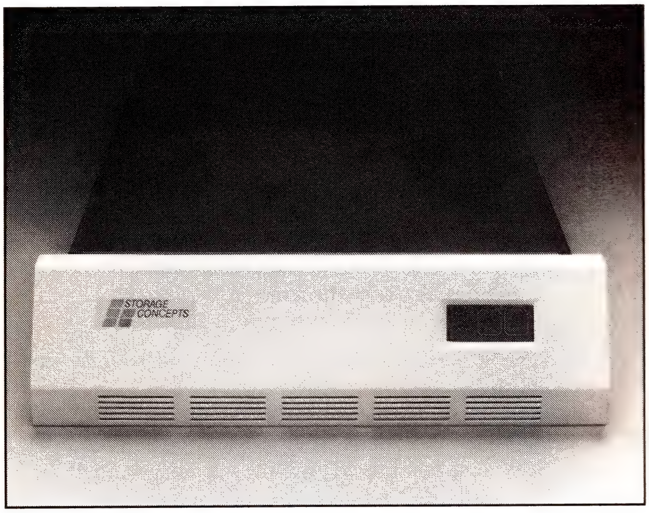
cations. The Concept 21, consisting of a proprietary controller and parallel transfer disk (the model M2350A from Fujitsu Ltd.), is being billed by the manufacturer as an off-the-shelf high-performance solution for original-equipment-manufacturer image processing.

Available with adapters for Multibus, Q-bus, Unibus, Versabus, and VMEbus computers, it is expected to be used primarily in medical imaging, simulation, animation, seismology, robotics, and computer-aided design, manufacture, and engineering. It can command five channels of disk I/O from a single drive, with each channel operating at 1.86 megabytes/s at peak speed.



The controller uses a proprietary formatting scheme to boost the peak transfer rate to 9.3 megabytes/s for five channels, each with a storage capacity of 474 megabytes.

The Concept 21 features a steady-state transfer rate of 8.1 megabytes/s, supports up to four parallel transfer disk drives, and supports automatic chaining of multiple I/O operations under its own control—independent of the host operating system. Single units sell for $17,700, and delivery takes four weeks.

Storage Concepts Inc., 3198-G Airport Loop Dr., Costa Mesa, Calif. 92626. Phone (714) 557-1862 [Circle 358]

Printer works with most personal computers

At speeds approaching 190 words/min, the low-cost Spinwriter elf can be configured for compatibility with most personal computers, including those from Apple, Digital Equipment, IBM, and Hewlett-Packard.

The Spinwriter elf is supported by most personal computer software, including Lotus 1-2-3, Wordstar, dBase, and Appleworks. It offers three pitches—10, 12, and 15 characters/in.—as well as bold and shadow print, bidirectional print, and an autoload feature.

The Spinwriter elf 370, priced at $545, is fully compatible with the IBM Corp. PCjr. The general-purpose model 360 sells for $595.

NEC Information Systems Inc., 1414 Massachusetts Ave., Boxborough, Mass. 01719. Phone (617) 264-8000 [Circle 359]

Two smart terminals sell for under $400

Market competition has pushed two terminals from different manufacturers below the $400 range. The new QVT-101 terminal sells for $395, while the price of the ESP-6110 was recently reduced to same price level.

The Qume Corp.'s QVT-101 and Esprit Systems Inc.'s ESP-6110 emulate the Hazelton 1500 series and Lear Siegler's ADM 3A model. The QVT-101 also emulates the Televideo 910 and provides 16 program functions. The ESP-6110 emulates the ADDS Viewpoint/Regent 25 and offers 14 program functions. Both terminals have 14-in. screens, an amber-screen option, and bidirectional ports. Current loop or RS-422 interfaces are also available with both products.

The ESP-6110's green phosphor display presents character matrixes of 9 by 12 dots. Each character position can be programmed for blink, blank, reverse video, underline, and dual intensity. The terminal operates at baud rates of 50 to 19,200. The QVT-101 transmits the entire screen contents to the host computer at one time, shortening transmission time. The terminal offers all the functions of the company's earlier QVT-102 model.

Qume Corp., 2350 Qume Dr., San Jose, Calif. 95131.
Phone (408) 942-4000 [Circle 357]
Esprit Systems Inc., 100 Marcus Dr., Melville, N.Y. 11747.
Phone (516) 249-3366 [Circle 369]

Uspice CAD software now runs on IBM PCs

Derived from Berkeley Spice2, a popular computer-aided-design tool for circuit simulation, PC-Uspice has been developed for use on IBM Corp. Personal Computers, PC/XTs, and compatibles. Required are 512-K bytes of memory, MS-DOS, and the floating-point coprocessor.

PC-Uspice retains the Berkeley input syntax, so all Spice input files will run on it. The software will accept either monochrome or color displays, and will work with any printer; it can also work with any pen plotter that uses the standard Hewlett-Packard Co. graphics language.

PC-Uspice runs at about half the speed of the VAX-11/750 version and can simulate circuits with approximately 150 to 200 active devices, depending upon the type of analysis desired. Other features include improved convergence, enhanced subcircuit capabilities, enhanced error checking, new MOS FET model parameters, and more.

Available now with user's manual, PC-Uspice carries a price of $1,050.

Unit Software & Consulting Inc., 1969 E. Broadway, Suite 1, Tempe, Ariz. 85282. Phone (800) 821-1989, ext. 941 (in Arizona, [602] 967-2202) [Circle 360]

C compiler release 3.0 optimizes automatically

C-language programs will run faster and more efficiently, the manufacturer says, with the optimization offered by this enhanced version of the company's C compiler—release 3.0. The optimization is performed automatically whenever a program is compiled, and for added flexibility, command-line options let the programmer select alternative optimizing procedures—or turn off optimization altogether.

Designed to let programmers write compact programs that execute quickly, this C compiler permits transfer of both the source and the object code for these programs from MS-DOS to Xenix and vice versa. This release of the C compiler conforms to the Unix System V standard and requires a minimum 256-K bytes of RAM, two double-sided disk drives, and MS-DOS release 2.0 or later.

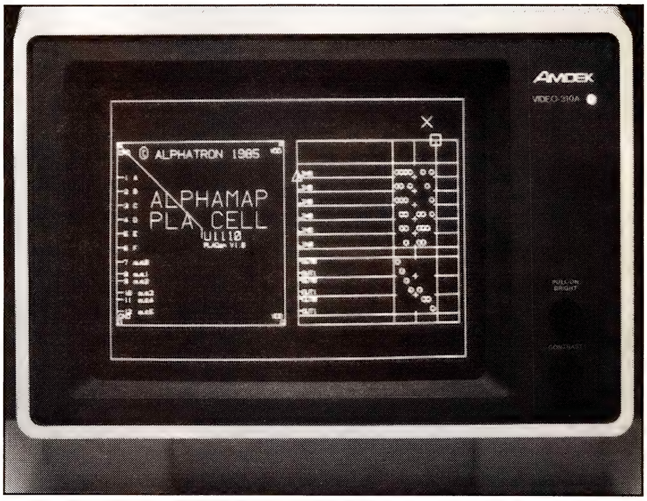
Programs written with the manufacturer's previous version of the C compiler (equivalent to Lattice release 2.03) can be recompiled with this release using conversion tools provided with the package. Owners of either the Lattice C compiler or this manufacturer's earlier version can upgrade to release 3.0; details are available from the Customer Service Department.

The suggested retail price of the compiler, including documentation, is $395.

Microsoft Corp., 10700 Northup Way, P.O. Box 97200, Bellevue, Wash. 98009. Phone (800) 426-9400 (in Washington, [206] 828-8080) [Circle 361]

Compiler builds custom PLA-cell library

Custom variable-size programmable-logic-array cells can be created automatically with the addition of this compiler to the manufacturer's Alphamap IC design system, which runs on the IBM Corp. Personal Computer, PC/XT, PC AT, and compatible computers. The software generates the cells in a format that is used directly for chip layout and logic simulation, creating the layout symbol to scale and generating the bit program.



In this way, the designer builds a custom PLA library cell that can be called up showing all I/O ports labeled, and with all the proper attributes that allow it to be used with any other Alphamap cell—placed, moved, rotated, mirrored, copied, and so forth.

Alphamap is a 3-μm cell library, priced at $3,500, with more than 100 cells that emulate the 74LS and CMOS 4000 series of ICs. The PLA compiler, an option, costs $900. Both are available immediately.

Alphatron, 10351 Bubb Rd., Cupertino, Calif. 95014.
Phone (408) 446-1494 [Circle 363]

Math software solves equations at a stroke

Mathematics without tears is the objective of Formula/One, a software package that lets the user solve equations, plot graphs, and perform other calculations on the IBM Corp. Personal Computer, PC/XT, and compatibles with 256-K bytes of RAM. The package can also perform multiple linear regression analysis.

The user enters the appropriate equation, supplies the known variables, and presses one key to solve for the unknowns, the manufacturer says. Function commands are full words, and the user can edit on-screen text and data with DOS-like key commands, such as pressing the insert or delete key.

No knowledge of programming is assumed or needed. The context-sensitive Help function clarifies the feature that the user has called without requiring a menu search. Formula/One provides a set of system-defined statistics, calculus functions, and the ability to perform multiple-linear-regression analysis; it offers 14-digit accuracy and an error-locating feature that moves the cursor to the point at which the mistake was made.

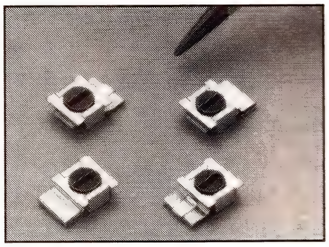
A report generator produces displays, reports, and graphs while bypassing any intermediate word-processing step. Each Formula/One package includes a disk with a number of completed models for applications in engineering and finance, plus documentation. The software, priced at $395, is available immediately.

Alloy Computer Products Inc., 100 Pennsylvania Ave., Framingham, Mass. 01701. Phone (617) 875-6100 [Circle 362]

Surface-mountable capacitor is tuned by a screwdriver

Designed for high frequencies, two surface-mountable precision trimmer capacitors can be adjusted with a screwdriver. The CPA2 capacitor has a range of 0.1 to 2.5 pF with a Q-efficiency rating of 1,000 at 250 MHz. The CPA10 offers the range from 0.5 to 8.5 pF with a Q of 500 at 250 MHz.

Both models have a minimum Q of 100 at 2 GHz. Self-resonance frequency is over 4.5 GHz, and self-inductance is only 0.3 to 0.5 nanoHenries. The part's temperature coefficient is ±100 ppm/°C.



The components measure 0.20 in. wide by 0.26 in. long by 0.09 in. high. They are suitable for extreme conditions and can withstand shock and vibration of over 500 g. Materials are compatible with all substrate and computer-board cleaning techniques.

Prices are less than 95¢ in 10,000-piece quantities, and delivery takes 6 to 8 weeks.

Voltronics Corp., P.O. Box 366, East Hanover, N.J. 07936. Phone (201) 887-1517 [Circle 350]

Ultramatched transistors offer wide current range

Two monolithic, ultramatched npn transistors maintain their input characteristics between 1 μA and 1 mA of collector current. The MPT-01 and MPT-02 transistors are designed for use in high-gain amplifiers and comparators. Another application for the parts is in nonlinear operations where the logarithmic relationship between collector current and base-to-emitter voltage is exploited. The MPT-02 conforms to the logarithmic function over a wide range of collector currents (from 1 μA to 10 mA), accurately implementing such nonlinear operations as multiplication, division, and square-root, or amplifying with log or antilog response.

In 100-piece quantities, the MPT-01 sells for $4.25 and the MPT-02 for $3.60 when packaged in TO-78 packages. Delivery takes four weeks.

Micro Power Systems Inc., 3100 Alfred St., Santa Clara, Calif. 95050. Phone (408) 727-5350 [Circle 351]

Band-gap references have 5% trim range

The three-pin ZNREF band-gap reference sources allow positive or negative trimmable output operation with low power consumption. Available in both commercial and military temperature ranges, the references can be used for instrumentation, analog-to-digital and digital-to-analog conversion, and power supplies. Four voltage outputs of 2.5 V to 10.0 V (±1%) are available, with a trim range of ±5% for fine tuning.

The components possess a wide reference-current range of 0.15 to 75 mA. They also feature slope resistance as low as 0.2 Ω and a long-term stability of 10 ppm/1,000 h. Custom voltages are available.

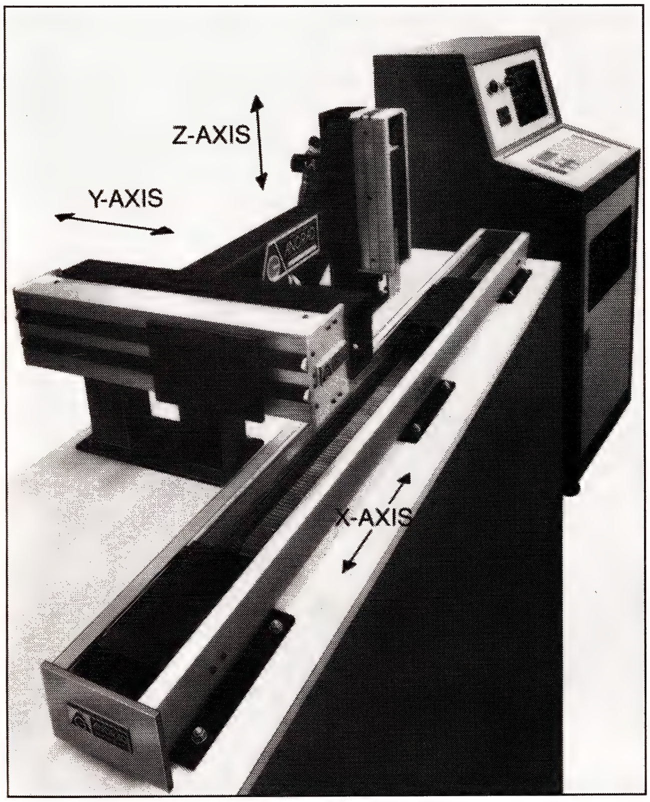
The commercial versions with 1% and 3% tolerances cost $1.90 and $1.50, respectively, in 1,000-piece quantities. In the same quantities, military models with 1% and 3% tolerances cost $5 and $3.73, respectively. The company needs approximately 8 weeks for delivery.

Ferranti Electric Inc., 87 Modular Ave., Commack, N.Y. 11725. Phone (516) 543-0200 [Circle 352]

Positioning system moves on a linear track

Linear IC motors drive this multislide positioning system, which the manufacturer says replaces linear stepping motors, rotary dc, and stepping motors with acme or ball screw drives, air and hydraulic cylinders, timing chains, and cams. The Anorail-5 features a short slide that rides on a hardened-steel U-channel base.

The slide can be set either horizontally, vertically, laterally, or in an inverted position. With a curved return channel of either 90° or 180°, an endless-track configuration can be set up. Linear optical encoders are combined with the Anoline linear dc servo motor for speeds up to 60 in./s and accuracies within 0.002 in./ft. Applications



for the Anorail-5 include robotics, parts transfer, and tasks requiring positioning actuation. Control method depends on the application.

The Anomatic II and Anomatic III programmable microprocessor-based controllers provide a stand-alone package for up to 16 axes of motion. An intelligent axis system offers an interface to a host computer for position, velocity, acceleration, and deceleration profiles. For applications that need point-to-point positioning, a two-position controller can be used.

Price and delivery depend on the customer's configuration requirements.

Anorad Corp., 110 Oser Ave., Hauppauge, N.Y. 11788.
Phone (516) 231-1995 [Circle 365]

Multiloop control system monitors heat processing

Multiple process-control functions can be integrated with the Star System for either localized or plant-wide control of heat-processing operations. The system makes possible up to 32 loops of set-point control over the VMEbus.

Hardware consists of Micristar, a microprocessor-based controller-programmer; Micricon, a multiloop controller whose independent microprocessor handles up to 16 loops of control and offers bimodal and cascade patching; Megastar, which controls up to 32 loops and has up to 64 I/O sequencing points. For centralized control, the Micrihost operator command station monitors up to 496 control loops and logs data to a display, to a disk, or to a printer; the Megahost supervisory command station provides for central data collection and reporting, material tracking, and master scheduling. In addition, the Megahost provides centralized communication to corporate computers.

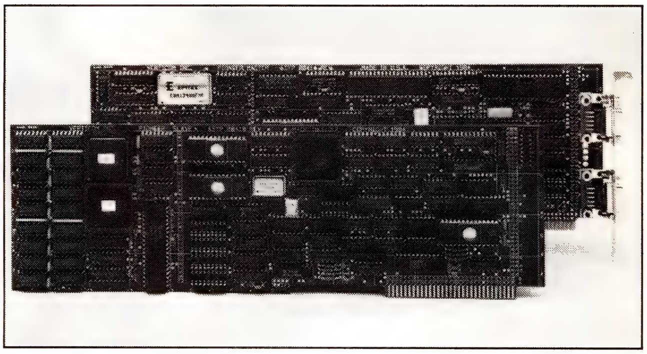
Series 662 power controllers come in capacities of 25 to 300 A, with a power rating of 15.6 to 249 kV/A. Complete systems of up to 10,000 A can be configured. The manufacturer will provide information on price and shipping time for the Star System.

RI/Control Systems Research Inc., 6425 Flying Cloud Dr., Minneapolis, Minn. 55424. Phone (612) 941-3300 [Circle 364]

Graphic controllers draw 1 million pixels/s

Two plug-in graphic controllers, the M-16 and M-256, draw images at 1 million pixels/s. The company attributes their speed to the 68000-based CPU and two proprietary 2-μm CMOS graphics chips. The M-16 and M-256 provide 16 and 256 colors, respectively, from a palette of 4,096.

The controllers work with the IBM PC AT, PC/XT, and PC Expansion Unit. Both support software that is compatible with the IBM Color Graphics Adapter and with the VDI and Halo graphics standards.



The boards, which the company says converts the IBM computers into low-end graphics work stations, are suited for computer-aided design and business graphics. Retail prices range from $2,250 to $2,850. Prices for original-equipment manufacturers are available upon request. The company also has the CD-1 color monitor with a 640-by-480-pixel resolution for $1,025.

Verticom Inc., 545 Weddell Dr., Sunnyvale, Calif. 94089.
Phone (408) 747-1222 [Circle 353]

Stacked DRAMs put 128-K in a single 16-pin package

Two 64-K dynamic RAM chips are stacked to produce the MSM37S664A, a 128-K DRAM module for use in the IBM Corp. Personal Computer AT and compatible computers. The product is offered in versions with access times of 120, 150, and 200 ns.

Fully decoded, the DRAM is organized as 128-K by 1 bit. Other features include 128 refresh cycles at 2 ms, noncritical clock-timing requirements, TTL-compatible I/O, and a single +5-V power supply with a tolerance of ±10%.

The MSM37S664A comes in a standard 16-pin plastic dual in-line package. In orders of 100,000 pieces, the 200-ns version sells for $7 each and the 150-ns model sells for $7.75 each.

Oki Semiconductor, 650 N. Mary Ave., Sunnyvale, Calif. 94086.
Phone (800) 336-3555 [Circle 354]

Internetwork router offers the best of two worlds

Combining the benefits of Ethernet (a baseband network) and broadband network systems, an internetwork router permits communication among up to 255 Ethernet networks over a single 6-MHz channel. The hybrid system operates over cable-TV-based broadband networks at signaling rates of 2 megabytes/s.

Ethernet offers higher-speed transfers and lower costs than broadband networks, but its 1.5-mile span can be too limiting in campus-like environments, the company says. When combined with broadband in the Gateway Server/6, however, Ethernet's speed and savings are merged with the community antenna TV system's five-mile range.

The GS/6, which uses a mid- or high-split single-cable system, features a modular architecture consisting of an Ethernet controller card, a 68000-based CPU card that executes the Xerox Network System of high-level protocols, and a high-speed, high-level data-link controller card that provides both carrier sense with multiple access and address recognition for the data stream.

An integral network management facility monitors line error, traffic statistics, and remote-loopback diagnostics for the GS/6. The router sells for $10,500. An annual license fee for routing software is $150. Delivery takes 60 days after receipt of order.

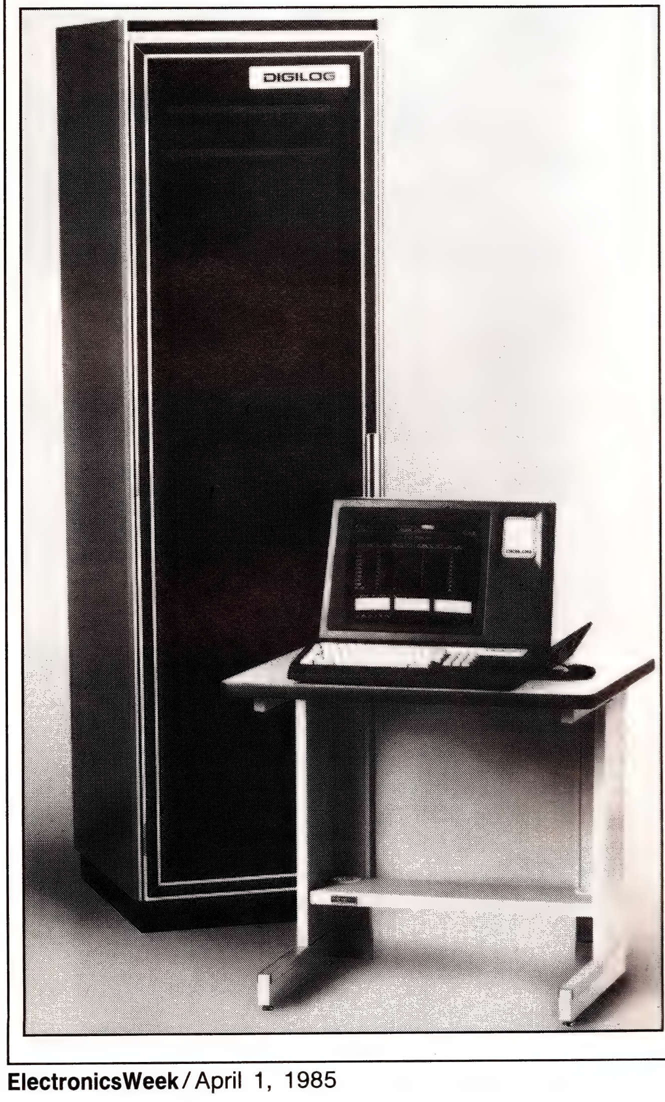
Bridge Communications Inc., 1345 Shorebird Way, Mountain View, Calif. 94043. Phone (415) 969-4400 [Circle 355]

Network-access switch can handle up to 1,440 ports

Redesigned to handle more ports, lines, and types of circuits at higher speeds, the Network Access Switch can now accommodate up to 1,440 analog or digital ports. It comes with a user-friendly operator interface that accepts simple English-language commands.

The microprocessor-based system houses the port cards that perform the switching, monitoring, testing, and alarm functions in card nests. Nests hold up to 15 port cards and two nest-control cards.

The maximum size of a single digital or analog nest is 120 ports; additional nest enclosures can be added to each cabinet, doubling the total to 240 ports. A single controller can handle up to six cabinets or as many as 1,440 ports.



With the system, an operator can mix digital and analog port cards within the same matrix. Digital cards provide either eight data terminal equipment or eight data communictions equipment interfaces; analog port cards support up to eight 4-wire ports.

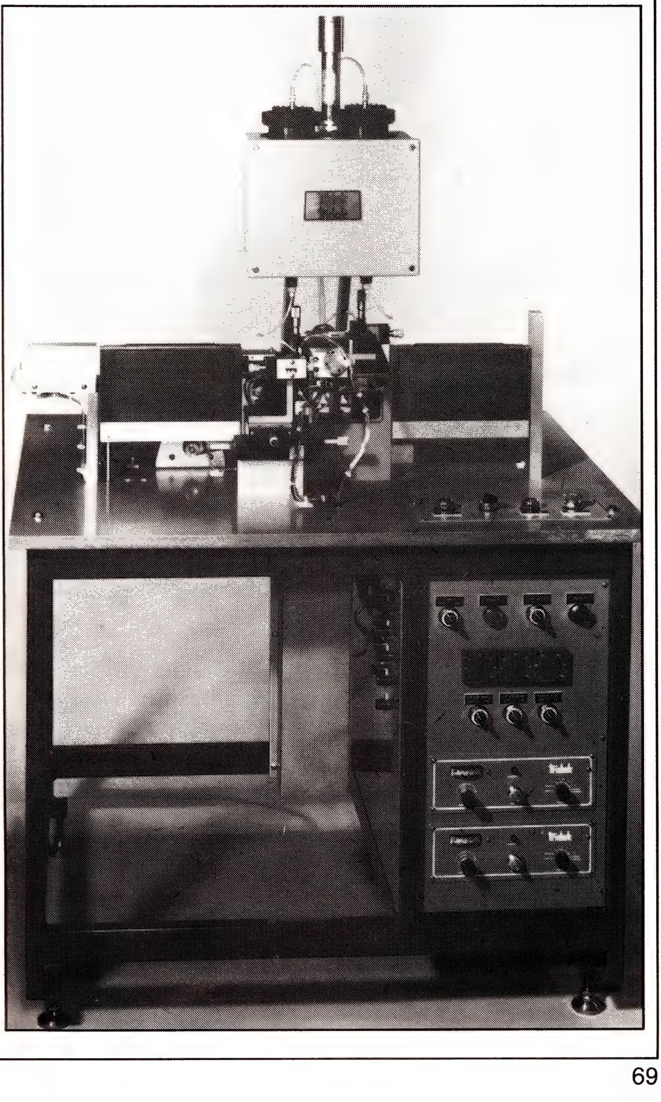
Prices start at $19,000 for the control system. Cards are an additional $1,170 each, and additional cabinets are $10,000 each. It is available now.

Digilog Inc., Network Control Division, 1370 Welsh Rd., Montgomeryville, Pa. 18936. Phone (215) 628-4530. [Circle 356]

Transport station offers choice of processes

Encapsulation, deposition of solder paste, attachment of dies with epoxy, and the dispensing of ultraviolet-curable resins are all possible with the 10,000 series transport station. This dispense station combines a magazine elevator and lead-frame indexer with a dispenser or pick-and-place system, or both.

The models in the 10,000 series can work at speeds



above 1 part/s coordinated with automatic magazine elevators. The design can be adapted to a wide range of magazines and lead frames.

The station's price—approximately $35,000—depends on the purchaser's requirements. Delivery takes six to eight weeks.

Indicon Inc., Tridak Division, 1120 Federal Rd., Brookfield, Conn. 06804. Phone (203) 775-1287 [Circle 367]

Loaded-board prescreener checks 1,024 points

The 55-165 prescreener hunts down defects in loaded and bare pc boards by testing up to 1,024 points. It checks resistance, capacitance, and junctions for shorts, opens, and damaged, missing, misoriented, or wrong-value components.

The operator can choose automatic, semiautomatic, or manual programming; test results are summarized automatically in a statistical error report and ranked by frequency. The 55-165 prescreener can also be used as an in-front tester, drawing upon existing fixtures for higher-level, in-circuit, and functional systems.

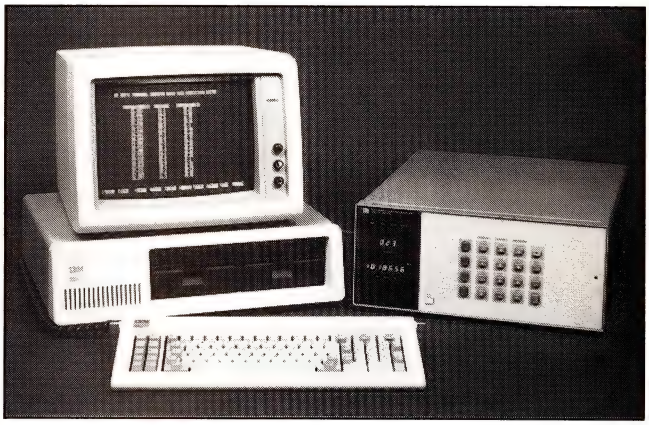
A complete system, configured for 1,024 test points and including the benchtop units and video display terminal, sells for under $30,000. Communications capabilities, hard-disk drive, and a printer are optional. Delivery is from stock.

Everett/Charles Test Equipment Inc., 2887 N. Towne Ave., Pomona, Calif. 91767. Phone (714) 621-9511 [Circle 366]

Microcomputer-based system provides full data acquisition

Personal computers operate as fully configured data-acquisition systems thanks to Hewlett-Packard Co.'s HP 3055S family of personal computer-based data-acquisition instrument modules and application software. The HP 3055S provides accurate analog and digital I/O, data storage, graphics, and analysis on the company's Touchscreen and Touchscreen Max computers as well as on IBM Corp. Personal Computers, PC/XTs, and PC ATs. Systems that can be configured for small, medium, and large-scale applications are available.

The system operates under a basic software package that utilizes a menu-driven application program. With the program, the user can set up an experiment, acquire and store data, and analyze the results by pressing soft keys or entering alphanumeric responses. For the more experienced programmer, the software also has user-callable subroutines for added flexibility.



Data can be gathered on up to 100 channels; the user can expand the system by up to 1,000 analog or 1,360 digital channels by adding extender chassis and writing a custom Basic program. Analysis routines such as channel versus channel and channel versus time can be performed on the software, which provides graphic displays and includes a utility program to convert gathered data to a Lotus 1-2-3 format. Additional instruments can be added to the system through industry-standard connectors.

Two hardware packages are available: the HP 3421A, for small to medium applications, and the HP 3497A, for larger-scale needs. Both feature 5½-digit integrating analog-to-digital converters, 1-mV sensitivity, low thermal relays, autoranging, autozero, and floating differential inputs. Both allow low-level measurements despite common-mode and normal-mode noise.

The HP 3421A, which can be configured for up to 30 channels of voltage, resistance, or thermocouple measurements, features isolated inputs, counter, electronic calibration, thermocouple compensation, and linearization. The HP 3497A features a nonvolatile clock and a choice of 12 optional plug-in assemblies. Each HP 3497A can be configured for up to 100 channels—up to 1,000 channels with extenders.

The HP 3421A costs $1,700, plus $400 for compatible software; software for the HP 3497A, which is priced at $4,650, costs $500. Delivery takes from four to six weeks after ordering.

Hewlett-Packard Co., Loveland Instrument Division, P.O. Box 301, Loveland, Colo. 80539. Phone (303) 667-5000 [Circle 343]

Letters

Hot foot

To the editor: Your editorial "Shooting oneself in the foot" [*ElectronicsWeek*, Feb. 18, 1985, p. 96] missed the critical point about proposed sales of Apple and IBM personal computers to the Soviet Union. Since we can't keep the Soviets from buying essentially identical products elsewhere, the least the government can do is get out of the manufacturers' way and let them sell where they can in the international markets. Otherwise, we truly shoot ourselves in the foot—as Carter's USSR grain embargo amply demonstrated.

Rick Cook
President, Fractal Systems Group
Phoenix, Ariz.

Competition everywhere

To the editor: "Trying to cope with the slump" [*ElectronicsWeek*, Feb. 11, p. 18] raises serious questions about the long-term competitive positions of U.S. chip suppliers.

We are in a battle for world markets with Japan, Korea, and Europe. Less capital spending, longer work weeks for designers, and wage freezes are tactics for coping with cash-flow requirements. Wall Street penalizes a company that doesn't produce quarterly growing profits, but isn't it time to look beyond the next quarter and examine the tradeoffs involved in loss of market share?

John P. Densler
Auburndale, Mass.

TI not even close?

To the editor: In the Up Front item "TI officially announces its 256-K DRAM" [*ElectronicsWeek*, Feb. 11, 1985, p. 10], you said "[Texas Instruments] is reportedly shipping about as many 256-K chips from its Japanese fabrication lines as are the island nation's own leading memory makers." TI, to my knowledge, has not come close to the million-piece-per-month ship rate, and at least three Japanese makers are shipping well in excess of that quantity.

Larry Clark
President, Hi-Tech Rep. Co.
Westlake Village, Calif.

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- What are the products, technologies, and strategies of companies such as AT&T Information Systems, InteCom Inc., Northern Telecom, United Technologies Communications Co., and others?

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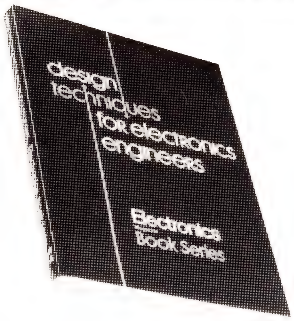

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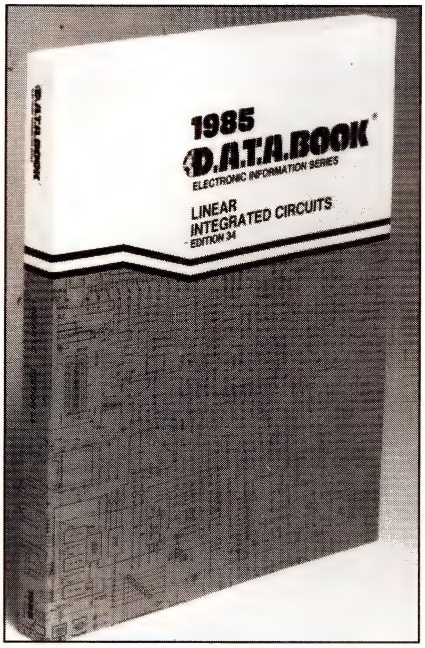
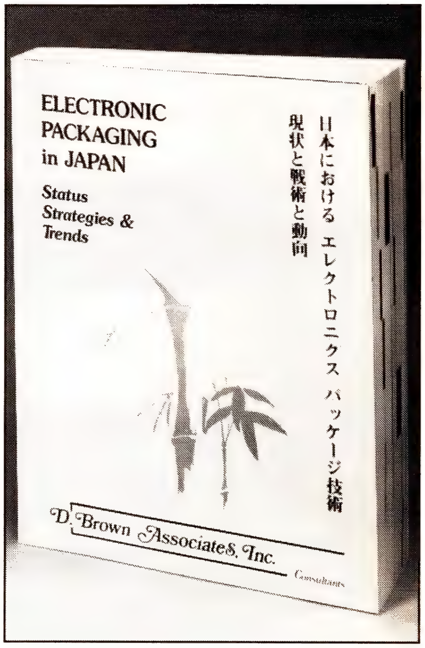


Linear acceleration. The 34th edition of *Linear ICs*, the standard industry reference source on linear integrated circuits, has arrived for 1985 with an expanded table of contents and a new format that for the first time divides technical sections into part types. Fifteen major component categories and 62 specific functions within those categories are furnished in the table of contents, so the user can go directly to the page with the necessary information. Circuit drawings are also easier to locate in the new edition, the publisher says, and a functional equivalence index cross-references currently available linear ICs from 80 manufacturers by pin-for-pin equivalence groups. New technical sections include transistor arrays, telecommunications products, and analog signal-processing parts; another innovation is the consolidation of manufacturer information into one section. Just published, *Linear ICs* is priced at $92. To place an order, call (800) 854-7030 (in California, [800] 421-0159; in Canada, [800] 674-1717). Or write to D.A.T.A. Inc., P.O. Box 26875, San Diego, Calif. 92126. [Circle reader service number 421]

Use it, don't lose it. The second edition of *A User Guide to the Unix System*, by Rebecca Thomas and Jean Yates, covers Bell Laboratories System V and Berkeley (the Berkeley vi screen-oriented editor appears on p. 243), as well as other Unix releases. Aimed at those who will not necessarily program under Unix—systems operators, for example—this book explains how to move around in the operating system, use the mail feature, create directories, and perform other standard Unix commands. It is more easily grasped by the nonprogrammer than manuals from Bell Labs or others. Word-processing applications are here for business users, and system administration is covered in an appendix. *A User Guide to the Unix System* is published by Osborne/McGraw-Hill Inc. The 520-page paperback volume sells for $18.95. Order it from booksellers or from the publisher, 2600 Tenth St., Berkeley, Calif. 94710. Phone (415) 548-2805. [Circle 423]

Carries a torch. As described in this literature, the Cyro 1000 robotic arc-welding work cell features five or six axes of articulated motion for access to hard-to-reach joint profiles while maintaining proper torch angles. The sixth axis eliminates the need for special torches or brackets previously required in many applications. A heavy-duty torch is standard, with chrome-zirconium contact tips; the 100% duty-cycle rating is 600 A with CO_2. Request a copy of this free brochure, "Cyro 1000: Work Cell with C-30 Controller," from Advanced Robotics Corp., 777 Manor Park Dr., Columbus, Ohio 43228, or call the company at (614) 870-7778. [Circle 430]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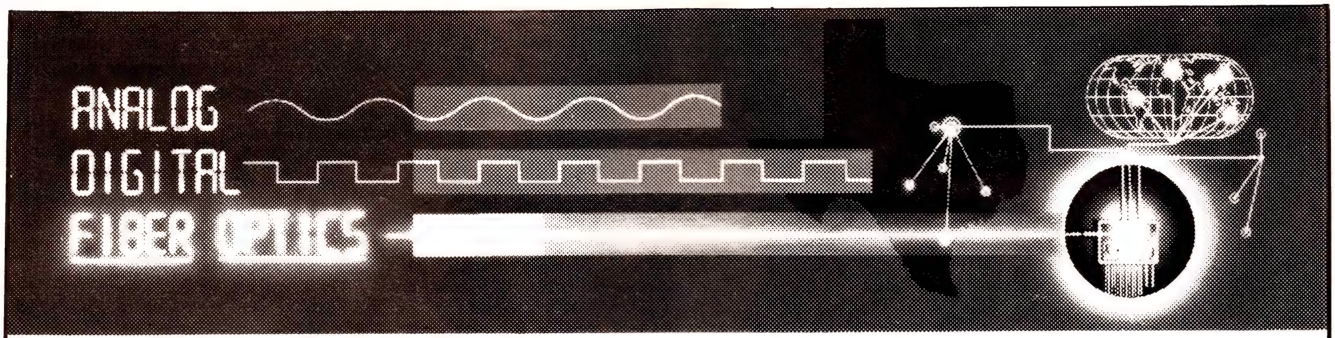
Packages wrapped here. A multiclient study from D. Brown Associates, *Electronic Packaging in Japan—Status, Strategies and Trends*, provides insights gathered from research conducted on site in Japan, including visits to suppliers of materials, components, hybrids, printed circuits, and lead frames. The preparers of the study also spoke with key advisers to several Japanese government agencies and representatives of Japanese technical societies. Users interviewed included manufacturers of consumer products, small and large computers, and telecommunications equipment. The results have been distilled into an analysis directed at U.S. manufacturers of commercial and military electronic equipment and suppliers of components. For more information on this study, including order information, contact D. Brown Associates Inc., 410 Commerce Dr., Fort Washington, Pa. 19034. Phone (215) 641-9100. [Circle 425]

Open gates. A technical bulletin describing RCA's power MOS FET device, the logic-level-FET (L^2FET), a 5-V gate-drive power MOS FET, also outlines a new method of characterizing switching performance in resistive-circuit applications. Because the L^2FET can be driven by 5-V power supplies, the manufacturer says, there is no need for the interface circuits or special 10-V supplies often required for conventional 10-V power MOS FETs. The reduction in the L^2FET's required gate-drive voltage from 10 to 5 V is the result of reducing the gate oxide by half, from 100 to 50 nm. The new method of characterizing switching performance described in the bulletin is based on gate and drain voltage curves developed by RCA. To order a single copy of the technical bulletin, "Switching Waveforms of the L^2FET" (application note AN-7254), call (800) 526-2177.



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Fiber Optics

Light Source Design

PhD/MSEE/Physics and minimum 4-6 years experience in 1.3-1.5 micron single mode semiconductor laser design. Experience in LPE/MOCVD, LED's, indium phosphite compounds, or DFB/EFB lasers desired.

Lightwave Component Design

MSEE/Physics and minimum 2-4 years experience in optical light sources, optical detectors, and wave division multiplex. Knowledge of guided wave optics, coherent wave optics, classical optics, optical alignment, lens and mirrors required. Position involves the design, test and measurement of WDM, laser diode to fiber couplings and optical attenuators.

Semiconductor Process Engineering

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Digital Hardware Design

BSEE with minimum 2-4 years experience in high speed digital circuit design. Experience with high speed digital logic, pulse code modulation, time division multiplex/demultiplex, real time signal processing required. Expertise with DS-1 and DS-3 signals desired.

Signal Processing Hardware Design

MSEE/BSEE with minimum 4 years experience in digital signal processing design. Requires knowledge of digital filtering, multiplex voice processing, signal processing between time and frequency domains and error detection methods.

Support Engineering

Software Development Engineer

BSCS or BSEE with minimum 2-6 years experience in software design and documentation on DEC minicomputers. Knowledge of C, PASCAL, software development practices such as structured design and structured programming required. Expertise in monitor and control systems and layered protocols such as CCITT X.25 desirable.

Quality Engineering

BSEE with minimum 4 years experience with customer quality evaluation, engineering troubleshooting and quality monitoring. Knowledge of automatic test procedures, HP network analyzers, HPL Basic and circuit design analysis is required. Position involves manufacturing engineering interface, customer contact and 10-15% customer premise travel.

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Test Engineers - BSEE or BSCS and 3+ years experience in commercial applications dealing with hardware/software testing for intergrated micro/mini-computer based real-time process control systems. Must be able to evaluate hardware/software test requirements, develop and/or review test plans and assist in the implementation of development and intergration tests. Software/hardware functionality includes man machine interface, communications protocol, analog/digital data handling/acquisition, data base and PDP 11/44 mainframe Intel 8085/8086 micro-computers.

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THE OLDER ENGINEER MAY BE A BETTER DEAL

The breakneck speed at which technology is changing means that engineers have more and more to learn. Such was the observation advanced by Ray Stata, chairman of Analog Devices Inc.; the venue was the Boston Museum of Science, where Dartmouth College's Thayer School of Engineering sponsored a forum on engineering education at which Stata was the keynote speaker.

Stata couched his suggestion in the context of professionalism: engineering has not enjoyed the same reputation and prestige as law and medicine, but that is changing fast. That is particularly true where successful entrepreneurs (he might have included himself) "have demonstrated that engineering can be the road to fame and fortune." Thus engineers should be better prepared.

That such preparation would be as helpful to engineering students as to anyone else is difficult to argue with. But another idea advanced at the forum by Stata and other participants is somewhat troubling. That is the proposal for engineering schools to consider a five-year program—the better to deal with hard-charging technology as well as with business matters.

Going to college for five years is not in itself a bad idea: the more one learns before going to work the better off one is. Physicians and lawyers put in more time than that now, and some pharmacy programs take five years to complete. As for who would pay for that extra year, Stata suggested a cooperative link between town and gown—companies could help with the financing.

We think that Stata and others like him, in their eagerness to improve the quality of young, beginning electrical engineers, are missing a more economical bet—the middle-aged professional. Wouldn't the employer of engineers be better off considering the more mature and experienced worker as the opportunity of first resort?

Consider the advantages of investing some, if not all, the fifth-year money in the further education of an engineer who has been on the job for 10 or 15 years. For one thing, the company has already invested a considerable sum, in the form of salary and benefits, in his or her education. Why ignore that investment in favor of starting all over with an untested neophyte?

Not only that, but there is some question about just how prepared the new graduate will be to step right in and go to work—no matter how much schooling he or she has had. Some things simply must be learned on the job, and the older engineer has already picked up most of them.

One example at the same forum came from William Davidow, former senior vice president at Intel Corp. He pointed out that young engineers, busily applying theory they learned in school, often do not realize the importance of tolerances and margins of error when dealing with quality control during production. Davidow suggested teaching them such matters. But the older engineer already knows these things by heart—in fact, they have become instinctive.

Finally, one other attribute that comes with years of experience—and only with years of experience—is recall, as in "I remember a problem something like that from when I worked at Everyman's Aerospace, and here's what we did about it." As that ageless sage, Anon, allegedly wrote: old age and treachery will always triumph over youth and skill. In the case of the mature engineer, substitute "experience" for "treachery."

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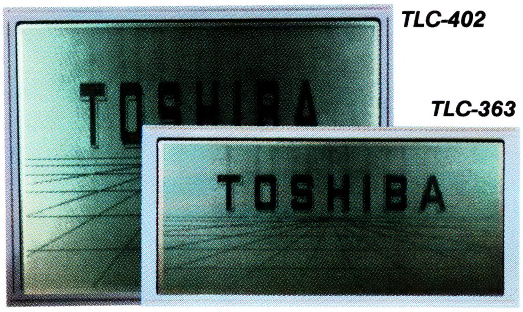

Specifications

		TLC-402	TLC-363
Display			
Number of Characters		80×25 (2,000 characters)	80×25 (2,000 characters)
Dot Format		8×8, alpha-numeric	8×8, alpha-numeric
Overall Dimensions (W×H×D)		274.8×240.6×15.0 mm	275.0×126.0×15.0 mm
Maximum Ratings			
Storage Temperature		−20 – 70°C	−20 – 70°C
Operating Temperature		0 – 50°C	0 – 50°C
Supply Voltage	V_{DD}	7 V	7 V
	V_{DD}-V_{EE}	18 V	18 V
Input Voltage		$0 \leq V_{IN} \leq V_{DD}$	$V_{SS} \leq V_{IN} \leq V_{DD}$
Recommended Operating Conditions			
Supply Voltage	V_{DD}	5 ±0.25 V	5 ±0.25 V
	V_{EE}	−13 V Max.	−13 V Max.
Input Voltage	High	4.0 V Min.	4.0 V Min.
	Low	0.5 V Max.	0.5 V Max.
Typical Characteristics (25°C)			
Response Time	Turn ON	300 ms	300 ms
	Turn OFF	300 ms	300 ms
Contrast Ratio		5	5
Viewing Angle		15 – 35 degrees	15 – 35 degrees

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